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Forthcoming Event.

JUNE 21–22.

British Foundrymen's Association: Annual Meeting and Conference at Sheffield.

NOTES AND COMMENTS.

Suggested Union of Technical and Scientific Societies.

As our readers are aware, considerable attention of late has been given to a suggested union of various scientific and technical societies. On March 14 last Sir Robert Hadfield reported to the Council of the Iron and Steel Institute the action taken by the special Committee appointed to consider means for raising a fund for the erection of a building in London to form a home for the joint societies. He had had an interview with the Minister of Reconstruction and Mr. Vaughan Nash, and Sir John Randles had consulted the Chancellor of the Exchequer and the Secretaries of the Inland Revenue as to obtaining powers for making contributions from excess profits to such a fund, with the object of housing not only the Iron and Steel Institute, but other technical societies, so that all might have the use of a common meeting room, and house their libraries in one section of the building. While expressing entire sympathy with the object in view, the Ministers and Treasury officials had expressed the opinion that under the statute it was not legal for contributions to be made from excess profits for such purpose, and consequently it would not be possible to sanction the proposal.

The President (Sir William Beardmore), after urging the desirability of making an immediate effort to raise a large fund for the purpose named, made a further suggestion, and a motion appointing Sir William Beardmore and Sir Robert Hadfield as a Committee to consider means for raising a large fund to provide a building to accommodate the Institute and other kindred societies, and to draw up a skeleton scheme for the further consideration of the Council, was carried unanimously.

It is needless to say the success of such a scheme has our very best wishes. Something will have to be done soon in the direction of co-ordination of, and co-operation in, research if we are to keep pace with the Germans who, with the Kaiser's approval, have, as we know, already founded a trust to further the development of scientific and technical aids to warfare.

Accident "Severity Rates."

In a report issued by the Bureau of Labour Statistics at Washington upon accidents and accident prevention in machine building, new data are introduced under the title of "severity rates," which show not only the number of accidents occurring in plant or industry or per thousand of employees, but also the extent to which the working forces employed have been actually incapacitated by injuries incident to their occupations. The meaning of the term "severity rates" may be best expressed by an example: Assume that a plant employing a thousand 300-day workers during the course of a year had 200 accidents, and that the total time lost by the men injured was 5,000 work-

ing days, the accident frequency rate for the year would be 200 per 1,000 workers, the "severity" rate would be 5,000 days lost per 1,000 workers, or, more conveniently expressed, an average of five days per individual worker. To make such computations, it is necessary, of course, to express fatal and permanent injuries, as well as temporary disabilities, in terms of work-days lost. This is done by valuing a fatal injury (assuming the employees killed of an average age of 30) as equivalent to the loss of 30 years' work time—9,000 days. Other injuries—such as loss of hand or foot are credited with lower time losses, in proportion to their probable effect upon earning capacity—2,196 days for a hand, 1,845 days for a foot, etc.

This method of evaluating permanent injury in terms of time loss, although based upon somewhat rough estimates, is by no means arbitrary. Severity rates, thus computed, constitute a much more accurate measure of accident hazard than do the older frequency rates. A striking example may be cited: The machine-building industry, in one year, had an accident frequency rate of 118 per thousand 300-day workers. This was, as it happened, actually higher than the accident frequency in a large steel plant in one year, the rate there being 114.5 cases per 1,000 workers. But when severity rates were computed according to the method described, the steel plant having a severity rate of 21.2 days lost per full-time or 300-day worker, as against only 5.6 days lost per worker in machine building. The investigation here summarised was based upon statistics covering 1912, that year being chosen because of the completeness of the figures obtainable.

As it was obviously impossible to cover all the plants engaged in the industry, the inquiry was limited to 194 typical establishments which worked 347,109,000 man-hours, which is equivalent to 115,703 full-time or 300-day workers. Classifying the combined plants by departmental divisions, boiler shops and yard labour show by far the greatest hazards. Boiler shops have a frequency rate of 224.1 per 1,000 workers, and a severity rate of 26.7 days lost per worker, while yard labour has a frequency rate of 221.1 and a severity rate of no less than 29 days lost. These rates are, roughly, as high as those in the iron and steel industry, which is recognised as inherently a much more hazardous industry than machine building. The analysis of accident causes, together with the determination of occupational rates, is at present the most important practical subject to be considered in accident studies. A careful study of accident causes was made in selected groups of machine-building plants. For the industry, as a whole, "falling objects" stand out as the most frequent cause of accidents, the frequency rate for five machine-building plants from 1907 to 1912 being 14.44 cases per 1,000 full-time workers, and for four machine-building plants, 1910 to 1913, 14.35 cases per 1,000 full-time workers. As measured by severity, "cranes and hoists" assume first place, the severity rate being 2.26 days lost per 300-day worker in the group of five plants, 1907 to 1912, and 1.22 days lost per 300-day worker in the group of four plants, 1910 to 1913. In foundries "hot metal" appears as the accident cause with most serious effects, the severity rate being 2.82 days lost per worker out of a total of 7.41 days lost for all foundry causes.

Depreciation Allowances.

A Memorandum has just been issued by the Board of Inland Revenue on the subject of allowances for wear and tear and obsolescence of plant and machinery. The existing law, as is common knowledge, authorises a deduction on this account of such an amount as the Income Tax Commissioners concerned "may think just and reasonable as representing the diminished value by reason of wear and tear during the year of any machinery or plant used for the purposes of the concern." This deduction is in addition to the allowance made in respect of the cost of *repairs*.

Variations necessitated by War Conditions.—In their statement the Inland Revenue point out that the rates of depreciation given in the Schedule were fixed *under pre-war conditions*, and they continue:—

Cases, however, have arisen, especially since the commencement of the war, in which machinery is suffering *exceptional wear and tear* owing, for example, to extra hours of running, the difficulty of obtaining material for effecting repairs, the rougher usage to which the machinery is subjected owing to the employment of unskilled labour, and the fewer opportunities available for having the machinery overhauled. In such cases applications for special rates of depreciation are entertained, but, generally speaking, the circumstances of individual cases are found to vary so widely as to render it impracticable to fix a uniform scale, and each application is dealt with on its own merits.

Obsolescence.—In addition to the allowance for wear and tear of plant and machinery there has been in operation since 1897 an allowance for *obsolescence*. Accordingly, where new and improved machinery is introduced in place of machinery not wholly worn out, the Board of Inland Revenue agree to the allowance, as a deduction from the profits of the year, of so much of the cost of replacement as is equivalent to the written down value of the machinery replaced less any sum realised by the sale of it—the balance of the cost of the new machinery being treated as an addition to the capital of the business.

Renewals.—As an *alternative* to the allowances for wear and tear and obsolescence of plant and machinery, the cost of *renewing* the plant and machinery may be claimed as a deduction in the computation of Income Tax liability under Schedule D. When this course is preferred by the taxpayer, the amount to be allowed is the actual cost of the new plant and machinery (excluding any part of such cost which is attributable to additions or improvements, i.e., to increase in capital) after deducting the scrap value or realised price of the plant and machinery replaced.

The full cost of maintaining trade premises in proper working order is allowed in computing profits for assessment.

"*Controlled Establishments.*"—In concerns which are "controlled," under the Munitions of War Act, 1915, the Income Tax allowance has been temporarily extended, by the Finance Acts of 1916 and 1917, to include the deductions for "exceptional depreciation or obsolescence of buildings, plant or machinery" which are allowed for Excess Profits Duty and munitions levy purposes. This allowance prevents the hardship that would otherwise arise owing to the circumstance that "controlled establishments," being held at the disposal of the Government, may be required to alter completely the course of their business and to undertake exceptional expenditure which may be of little or no post-war utility to them. The Finance Acts of 1916 and 1917 accordingly authorise the Commissioners to revise the Income Tax allowance so as to enable a deduction to be made from profits of the difference between cost and post-war value of installations and extensions (including buildings) which would not have been undertaken but for the war and the express requirements of the Government.

Die-Casting of Aluminium-Bronze.

By H. Rix and H. Whitaker, M.Sc.

Die-castings may be defined as "finished castings, made by pouring molten metal, flowing by gravity or under other external pressure, into a metallic mould." Some of their advantages are:—(1) Accuracy and uniformity. They can be made to specification 0.005 per in., or even less for small parts. (2) Machining costs are either eliminated altogether or are greatly reduced. (3) The process is continuous, and the output is generally much greater than is the case with sand-casting. (4) Articles which it would be impossible to sand-cast may be successfully die-cast. The process has only during the last ten years assumed importance as a separate industry.

The alloys employed may be divided into five classes, according to whether the principal constituent is (1) zinc, (2) tin, (3) lead, (4) aluminium, or (5) copper. Owing to their low melting points, alloys of the first three classes were initially employed, but the castings lacked strength and rigidity. An average zinc-base alloy has a tensile strength of about 8 tons per sq. in., with practically no ductility. Moreover, these alloys are liable to corrosion and distortion. The tin- and lead-base alloys include a large number of the "Babbitt" or other bearing metal type, and many bearings are now being die-cast.

The low specific gravity, cheapness, and strength (when alloyed) of aluminium have been the principal factors in its development as a die-casting metal. The chief drawbacks are:—(1) Its high melting point (compared with lead, tin, and zinc). (2) Its tendency to attack iron when molten. (3) Its high shrinkage. (4) Its weakness at high temperatures. On account of (2) the "plunger" type of machine has been largely superseded by one employing air-pressure, or by utilising the pressure of the riser or gate. A die using zinc-base alloys lasts almost indefinitely, but, when using aluminium alloys, cracks begin to show after two or three thousand castings have been made. The high shrinkage of aluminium has been reduced by alloying, and need not exceed about 1.4 per cent. The weakness of the alloys at high temperatures is responsible for the formation of cracks which develop while the metal is solidifying in the mould. Thus the strength of the copper-aluminium alloy containing, say, 12 per cent. copper drops from 8-10 tons per sq. in. at 0 deg. C. to 3-5 tons at 350 deg. C. Notwithstanding these drawbacks, aluminium alloys of very variable composition are being successfully die-cast on a large scale.

The next step in the process of die-casting was to surmount the difficulties connected with copper-base alloys, which have a much higher melting point. The chief difficulty in the process is the high temperature (900 deg. to 1,000 deg. C.) for casting "yellow metal."

The zinc in the brass attacks the steel die, which rapidly deteriorates, so that no more than 1,000 castings can be obtained. The high shrinkage of brass sets up strains within the die which further impair its accuracy. Since the die-cost (anything from £5 to £200) is the prime factor in die-casting, this is a serious matter. For the same reason it is impracticable to use an iron container for the molten metal, as the alloy would rapidly become contaminated thereby; hence air pressure cannot be employed to force the metal into the die. This means pouring from the crucibles, with consequent slowing down of production, if only one die can be used. Another consequence of the high temperature and slow pouring is the large amount of dross which is formed. Also, ordinary brasses are not sufficiently strong at high temperatures to withstand the shrinkage strains which are set up. It is very difficult to produce brass die-castings which are consistently free from blowholes or shrink-holes. The former are caused by air being entrapped in the mould, and they cannot be overcome by simply increasing the pressure in the mould or by carrying out the process *in vacuo*. By a careful study of the venting and gating of each part, however, this unsoundness may be practically eliminated. Brass and bronze die-castings are only a commercial success if the parts cannot be completely produced by automatic machinery, or when they obviate numerous difficult machining operations, involving different settings of tools. To compete with the machined products the die-castings must be rapidly made, must be accurate ± to within 0.002 per in., and must have a smooth polished surface. Recent developments in foundry and machine-shop practice have made it possible for many parts to be now more cheaply sand-cast, and "yellow" metal die-casting is practically restricted to pieces of fairly simple shape, weighing between ½ oz. and 3 lbs.

The experiences of the authors in this connection have been chiefly in the use of brass (60: 40) containing about 2 per cent. aluminium, of manganese brass, and "aluminium-bronze" containing iron. In the case of manganese brass the usual composition, containing less than 1 per cent. manganese, with a little iron and aluminium, is used. The best results have been obtained by the authors with "aluminium-bronze" containing iron. The first alloys experimented with were of copper-aluminium containing about 10 per cent. aluminium, the balance being copper, but the results were disappointing, and after repeated trials it was decided to add a little iron, when much better results were obtained. Vickers alludes to the prejudice which appears to exist in the minds of most foundrymen against iron in copper alloys, probably due to its harmful effect when present in brass in any quantity. While claiming that it improves the metal for sand-casting, he questions its use in die-casting, for the following reasons:—(1) In sand-castings it is necessary to add iron in order to prevent the excessive crystal growth which is such a drawback to the 10 per cent. aluminium-bronze. In die-castings this is not necessary, as the chilling effect of the die is sufficient to keep down this growth. (2) Iron accentuates the shrinkage of the bronze, consequently increasing the tendency to form the pear-shaped cavities commonly found in aluminium-bronze die-castings. The authors do not agree with the above conclusion limiting the usefulness of copper-aluminium-iron alloys to sand-castings, having produced many thousand die-castings in these alloys.

The cavities referred to are certainly a difficulty

* Paper read before the Institute of Metals, March, 1918.

to be overcome. They are either shrink-holes, caused by the large contraction of the metal, or blowholes caused by air being entrapped in the die by the molten metal, and they may be detected in a casting by finding its specific gravity. Their direction is often radial, and they may be coloured black inside. In either case, they may be practically eliminated by a careful study of gating, venting, etc.

Tetmajer has worked with "aluminium-bronze" containing iron and silicon, but what appears to be the most comprehensive account of the copper-aluminium-iron alloys is by Corse and Comstock.† They have studied the properties of the possible combinations containing 1 to 4 per cent. iron and 7 to 10 per cent. aluminium inclusive. Their conclusions are that "for the same aluminium content there is always an increase of proportional limit, yield point, and ultimate tensile strength with increasing iron content, and in general a rather less substantial decrease in elongation and reduction of area. In the same way, with constant iron content, the proportional limit, yield point, and ultimate tensile strength increase with increasing aluminium, while the elongation and reduction of area decrease. Also, that for a given strength, better ductility can be obtained with a lower aluminium and high iron alloy, than with higher aluminium and low iron."

It is, of course, difficult to compare the results of different workers on similar alloys, owing to lack of uniformity in methods of preparation and testing, but a comparison of the results contained in the Eighth and Ninth Reports to the Alloys Research Committee, and those obtained by Corse and Comstock leads to the following conclusions:—

(1) Iron and manganese, when added respectively to copper-aluminium alloys (containing 7 to 10 per cent. aluminium), have a similar effect, *i.e.*, the yield point and ultimate tensile strength are raised at the expense of the ductility.

(2) In the case of sand-cast bars, the addition of iron appears to give better all-round mechanical properties than the addition of an equal amount of manganese. The data are not available for a complete comparison of the chill-cast bars, but some promising results have been obtained by the authors with alloys containing 7 to 10 per cent. aluminium and 1 to 4 per cent. iron. The authors are producing die-castings commercially in one of these alloys, and the following are the average results recently obtained from twenty-four test bars, cast in 1 in. chill and cooled in air, each bar representing a batch of castings, produced consecutively during a period of several months, under ordinary foundry conditions:—Diameter of test-section, = 0.564 in.; yield point, 14.7 tons per sq. in.; ultimate tensile strength, 35.5 tons per sq. in.; elongation on 2 in. per cent. 24; reduction of area per cent., 21.8.

These results compare favourably with those for the chill-cast bars containing 7 to 10 per cent. aluminium given in the Eighth Report, and for those containing 8 to 10 per cent. aluminium and 1 to 5 per cent. manganese given in the Ninth Report. In several cases the latter alloys give better results, but whether they may be die-cast or not is open to question.

The mechanical properties of the copper-aluminium-iron alloys may be profoundly modified by heat treatment. Consequently accurate pyrometric control is advisable, if consistent results are required. The temperature of the molten metal should be known, and that of the die itself, also the rate of cooling of the hot casting should be standardised. An advantage of the alloy used by the authors is that it is sufficiently fluid to fill the die and give satisfactory castings through a wide range of temperature.

The authors have experimented with several materials, ferrous and non-ferrous, for die-making, but have had the best results with a close-grained cast iron, as hard as is consistent with good machining. The block of iron from which the die is made is itself chill cast, to give these qualities. It need not be pointed out that a die when once made is only suitable for one particular alloy. Each alloy has its own requirements regarding gating, venting, and shrinkage, and the particular problems of each new part render it very difficult to make a correctly designed die at the first attempt. The design of the die is a most important factor, and the design of the part itself should conform to the special requirements of die-casting. There is need for the closest co-operation between the engineer, metallurgist, and foundry foreman.

No general rule can be laid down with regard to the cost of the process. In some cases die-casting is cheaper, in other cases dearer than sand-casting. Thus, for instance, the cost of machining and assembling of a "Butterfly" type carbon brush-holder is eight times as great when sand-cast as it is when die-cast. The castings are not sold by weight, as the cost of labour varies both in making the dies and castings. The die cost is treated as a separate item from that of the castings, and is generally borne directly by the customers.

Discussion.

MR. T. G. HIRST said that he had found, in using iron, that it did not completely alloy, and that it left small back spots in the finished die casting.

MR. F. JOHNSON referred to a Paper of his in 1916 before the British Foundrymen's Association in Birmingham, in which he dealt with the production of die castings in non-ferrous alloys, particularly brass, and in which he had pointed out that when such alloys became a commercial proposition there would be a revolution in the manufacture of castings. He was, however, thinking particularly of the copper-tin or copper-zinc alloys on account of their relative cheapness. It occurred to him that in addition to the advantages of using the ordinary aluminium alloys which had been pointed out in the Paper, there was also the advantage that the aluminium present formed an external skin of alumina, and that that external skin prevented contact between the zinc of the brass and the iron of the mould. At the time he read his Paper he had had submitted to him a perfect example of a brass die casting containing about 64 per cent. copper, a little lead, and 0.3 or 0.4 per cent. of aluminium, but he had had no further news as to whether it was a commercial success, though he saw no reason, since the author had shown that cast-iron dies could be used, why brasses which contained a small quantity of aluminium should not be made on a commercial scale. The influence of iron was very interesting, and he asked the authors if they had any experience of copper-aluminium alloys containing iron, say, 10 or even 15 per cent. There were certain uses for alloys of that kind in service at high temperature. They would perhaps have less fusibility and less fluidity. This latter was a point upon which he thought the authors had insisted insufficiently

† Transactions of the American Institute of Metals, Sept, 1916.

in the Paper, nor did the Paper insist on the property of fluid shrinkage as compared with contraction in the solid. Had the authors any experience or could they suggest the possibility of putting copper-tin alloys on the market in die-cast form as a commercial proposition?

Mr. P. Peakman (British Westinghouse Company) said that when he first went to Manchester his company was making die castings of all shapes and sizes very successfully. Difficulties that were encountered with shrinkage in certain aluminium die castings were largely due to the temperature to which the metal had been subjected in the crucible, and also the temperature at which the metal was poured. In some foundries it had been found better to strip the die from off the semi-solid casting as a means of eliminating the shrinkage cracks to a very great extent. In others an advantage was found by top-feeding die castings, particularly with aluminium, whilst other people poured from bottom-fed dies or side-fed dies. In this way many of the troubles of pouring die castings might be eliminated. With regard to aluminium-bronze, it would be interesting to know if it were possible to apply some outside pressure other than that given by the head of metal in the jet of the die. Blow-holes or air pockets which had often been found could be greatly reduced if more care were taken in the crucible stage. The authors had suggested that certain investigations would be of great value to the die-casting industry. He would like to know, however, how that information was to be interpreted into foundry language. It had been found up to the present that die casters wanted plenty of capital, plenty of patience, and the requisite brains, and that without these die casting was a failure; therefore, it was necessary that the information mentioned in the Paper should be interpreted for the benefit of the industry. There was much room for investigation into the composition of the metal used for the dies, and particularly in respect of the various portions of the die. The Westinghouse Company had found cast-iron dies good and cheap, but the plugs used were of a different metal altogether. He wondered whether it would not be possible to have a different facing to the plug than the material of which the die itself was made.

Prof. C. A. Edwards said he could not help feeling that ultimately it would be found that the best die to use would be made of something other than cast iron. A possible material was that of which the actual die castings were made, an advantage of which would be the protective coating of aluminium; he believed this would protect the mould from the action of the liquid metal. All that was wanted was plenty of mass in the die so that the rate of cooling from the casting into the die would be at the proper rate. If that was not found to be satisfactory—it was satisfactory in some works—there was another alloy and that was a modification of Monel metal, which was a homogeneous solid solution, and might be harder and better from that point of view. He had often wondered what the effect of the iron in the alloy was. At present it was a mystery. Die casting with copper-aluminium could not be done very expeditiously, but it could be and was being done fairly satisfactorily. A possible explanation of the beneficial influence of iron in this connection might be found by reference to the copper-iron diagram. Iron was the first element to crystallise from the relatively rich copper-iron alloys, and he thought that the iron first of all crystallised and flowed practically to the surface of the metal and prevented excessive oxidation and the excessive formation of the surface film of alumina which was so objectionable.

All who took up die casting should bear in mind one or two details. Wherever possible, always cast according to the rules laid down for hydraulic casting, viz., from the lowest possible point in the mould, and, wherever it could be arranged, always have a long runner—as long as possible. That always produced a cleaning and a clearing effect as regards the alumina surface. Cast iron should not be used, but only the purest of wrought iron. Silicon was absolutely fatal. Further, the alloys should be melted at as low a temperature as possible, so that in the melting period silicon was not taken up. He would like the authors to investigate one point. The future of die castings would rest very largely on the knowledge of how to treat them. The authors had selected an alloy which gave the least trouble, not necessarily the best results, although that, of course, was quite the proper thing to do in the first place. The die casting of these alloys, however, would utimately resolve itself into the adoption of duplex structures; they could be produced and were being produced, but it was necessary to know the different properties that would exist in the different sections of the casting, because the rate of cooling had such an enormous effect on these alloys, not so much with the ones the authors had used. It was no use assuming that they were getting certain mechanical properties in the casting as a whole, because in different parts it might be entirely different with the alpha-beta alloys. He did not think manufacturers need hesitate so very much in taking up this question. He knew of one foundry that twelve months ago had not seen any bronze die castings, but three months afterwards they were producing thousands for the Admiralty.

Dr. W. Rosenhain said he had seen the operations referred to in the Paper carried out at the works where the authors had developed their methods with admirable precision. A chill-cast alloy was usually stronger and more ductile and a better metal than the same composition of metal cast in a sand mould, and those qualities were vital in the fittings that the authors were engaged in manufacturing. He should not have thought that the alloy referred to in the Paper, viz., 12 per cent. of copper, was one which was particularly remarkable for its strength at high temperatures. It was possible to get alloys very much stronger than that at the high temperatures referred to in the Paper. The risk of cracking and annealing was very much diminished, but the difficulty of shrinkage had to be got over by stripping the die at the right moment, not too soon and not too late. That was a matter partly of experience, but it could be assisted by knowledge of the physical properties of the alloys at high temperatures. With regard to the action of iron, he was not prepared at the moment to definitely give a reason for this, but there was reason to believe that iron would be present in combination with aluminium, and that it would crystallise out from its metallic solutions at a very high temperature, and in that way it would materially resist shrinkage. This, however, was a little speculative. He regarded the production of these castings as a remarkable achievement.

Mr. John Dewrance said he had been die casting for 30 or 40 years, and he was a little surprised that cast iron should be recommended for moulds. His experience with cast iron in connection with ferrous metals was that in pouring the metal

parted with its gas and caused trouble. Perhaps this effect might not be so great with these alloys. It was so with tin-copper alloys, and he had found nickel or wrought iron very much better where the castings had to be free from blow-holes. The life of the chills was also a matter of very great importance in considering the cost, because for some reason cast iron after being used for a certain time changed. They got very brittle and distorted. The difficulty of withdrawing all the internal portion at the exact psychological moment was at times so great that the engineering side of the establishment frequently preferred actually to machine out the internal portions rather than to depend upon the risks that resulted from some carelessness in heating at the right moment, and in producing the internal core out of the actual mould. For that reason, quite a number of his die castings had their internal part machined out, and if that was done in any quantity it was found to be more reliable in the ultimate result. He had found the use of plumbago and various cements, such as shellac and lacquer, very beneficial in preventing the metal from pressing on to the mould. This was not necessary for the more fluid metals, but with nearly all the tin alloys he had used it was necessary. In each case, however, it would be found that there was some particular dressing which was particularly successful.

THE PRESIDENT asked the authors which particular form of pyrometer they had found most suitable. As regards the structure of these alloys, the figures in the Paper showed that a certain percentage of iron, varying with the amount of aluminium, was dissolved in the alpha solution. Above a certain point the iron came out in the form of well-defined crystals, and undoubtedly one of the results of the addition of iron was to diminish very considerably the size of the crystals. Exactly why that should give the better finish to the castings was not very obvious, but the fact was there.

MR. WHITAKER, replying to the discussion, said he had tried the tin-aluminium alloys, as suggested by Mr. Johnson, but gave them up in favour of the aluminium-bronze, for the reason that they gave a bad surface. He did not think it was much use increasing the quantity of iron above, say, 6 per cent. at the outside. If they did, although the ultimate strength might be increased, the ductility decreased to a very low value. He had no experience of copper-tin alloys in connection with die casting. He fed his castings from the bottom, and that was done with the idea of getting a better surface. If it was a case of getting as perfect a surface as possible, he always fed from the bottom. The only objection to that was the increase of scrap, although, of course, it was always remelted. That, however, was an expense, but it was the only objection to feeding from the bottom. It was often more economical to put up with a rough surface and a little bit of machining than to get a perfect surface straight away. As to a standard die, perhaps the butterfly type, with which he always tried a new alloy, might serve as a useful start. He had found that if an alloy would make a satisfactory casting in that die it would probably make one in any of the other dies as well.

MR. PEAKMAN said that apparently the authors blew the metal straight in against the plug. Did they find the plug was worn away by the continuous flow?

MR. WHITAKER said the plugs did wear away sooner than the rest of the die. The plugs he used, were made of high-speed steel—chrome-tungsten—but the drawback to them was that they warped and had to be renewed two or three times during the life of the die. In reply to Prof. Edwards, he had not actually tried a die made of aluminium-bronze, but he would do so and make known the results. He used wrought iron and not cast in his alloy. The form in which he introduced it was horse-shoe clippings, quite small pieces of iron which he had analysed and found extremely pure. It very quickly got absorbed by the alloy. The variation in strength of a casting, according to the sectional area, was important in connection with test bars and specifications for die castings, because it was extremely important to know exactly what was the strength of the casting and not of the test bar. He admitted he had had some opposition to meet in connection with this alloy in regard to soldering, but he believed it was possible to do so by first dipping it in molten zinc. In regard to Mr. Dewrance's remarks on treating the mould, he had tried all manner of things to protect the surface, but had not found anything which was thoroughly satisfactory. He had tried graphite wash, various kinds of oil, French chalk and finely-divided silica, but he had never found anything which would prevent the molten zinc from attacking the die. As to the pyrometer, he had not used one at all. He was convinced, however, that if there was a greater pyrometric control of the process consistent results would be obtained. At present, however, it would mean a dozen or so pyrometers, and they would have to be platinum-couple pyrometers at that. He had not been able to get one that would stand up to the rough treatment in connection with these alloys. He had been looking for the best type of pyrometer for a brass foundry, and the type he was going to use was one devised by the physicist at the Westinghouse works. It was a radiation type using a black-body surface, black carbon inserted in two pieces of steel and small thermo-couples at the top of the instrument, and these would be connected up to the ordinary milli-voltmeter. The difficulty was that if an iron sheath was used it was attacked very rapidly, and for this reason they had had to fall back on the radiation type, the optical type being no good for the purpose.

Tin and Tungsten Research Board.

As the outcome of a conference held on November 7, 1917, at which there were present representatives of the Committee of the Privy Council for Scientific and Industrial Research, of the Department for the Development of Mineral Resources, and many of the land and mine-owners of Cornwall, a fund for research has been raised and a Research Board has been appointed by the Committee of the Privy Council consisting of :—

Sir Lionel Phillips, Bart., chairman; Mr. John G. Gilbert, Cornish Chamber of Mines; Sir Frank Heath, K.C.B., Department of Scientific and Industrial Research; Sir Thomas Kirke Rose, chairman of the Research Committee of the Board; Mr. Edgar Taylor, Institution of Mining and Metallurgy; Mr. R. Arthur Thomas, Cornish Chamber of Mines; Sir Richard Threlfall, K.B.E., F.R.S., Advisory Council for Scientific and Industrial Research; with Mr. A. Richardson as secretary (15, Great George Street, Westminster, S.W.1.)

The Board, after consultation with their Research Committee, have authorised extended lines of research with a view to increasing the recovery of metal in the treatment of ores.

Tilting Melting Mixers and Steel Furnaces.

By H. Stonewall Jackson.

In view of the developments taking place in the steel-making industry of this country, it may be of interest to review the progress which has taken place in the design of tilting metal mixers and tilting steel furnaces. One of the first metal mixers used in this country was the one of the converter type installed at the works of the North-Eastern Steel Company. This was of the storage or non-active type, but later two active-type 400-ton mixers were installed, of which particulars are given later. Most of the mixers used in this country are of the active type, whereas on the Continent the non-fired or merely storage type are probably most common where the minette ores are worked. Although the earliest form of mixer installed was the converter non-fired type, very good results are being obtained by fitting them with burners. Mixers of this type are doing very satisfactory work up to 200 tons capacity. Owing, however, to its restricted openings for charging, this type is not very suitable for taking in scrap. They are usually operated by means of a single-acting hydraulic cylinder, and the mixer is so balanced that its weight brings it back to zero when the pressure is released off the tilting cylinder.

Another small-capacity mixer (100 tons contents) which has proved satisfactory is of semi-circular form, carried on flat stands and tilted by means of two single-acting cylinders on the opposite side to the pouring, the weight of the mixer bringing it back to rest. For mixers of larger capacity the semi-circular form has almost universally been adopted. It is easy of manufacture and strong in design, and admits of large charging doors which can be arranged for taking in scrap or refining agents. These large mixers, which have been made up to 750 tons' capacity, are usually carried and tilted on four, eight or more rollers, the roller bearings being of cast iron of ample surface, but usually bushed with bronze. An important point is the provision of efficient means of lubrication, the lubricators being fitted on the ends of the roller shafts, and the lubricant passing through holes drilled transversely through to the bearings in which are cut oil-grooves. The rollers are of cast steel running on rockers fitted round the mixer. The rockers themselves were originally made of cast steel, but the cost became prohibitive, as it was found that the steel-founder could not make castings which did not necessitate the machining of both surfaces, *i.e.*, the surface fixed to the mixer and the rolling surface. This led to the rockers being built up of sectional material, with excellent results and at much less cost. It is imperative in the manufacture of structural rockers that the workmanship be of the best and that the struts between the inner and outer boom plates be a perfect fit. The roller boom plates are usually from 1½ in. to 2 in. thick, and this provides a perfect rolling path without any machining. As the bearings carrying the trunnions of the tilting cylinders are fitted so that no lateral movement of the cylinders can take place, which is essential owing to the connections to the cylinders, clearance must be provided for expansion at the top end of the tilting-cylinder piston rods, *i.e.*, the crosshead pins on the rockers, otherwise bent piston rods may be experienced. In some instances the stands carrying the mixers carry the roller bearings, these stands being made of cast-steel box section; structural stands carrying the roller bearings are equally efficient and cheaper. The roller shafts are sometimes made of nickel steel, but if they have ample surface this is not necessary, as ordinary mild steel has proved efficient.

As regards tilting, this is usually done by means of hydraulic pressure with either four single-acting or two double-acting cylinders. The latter are certainly much cheaper, and if care is exercised in the designs of the pistons they are efficient, but amongst certain steelworks' engineers there is a prejudice against their adoption if the single-acting type can be fitted.

The charging and inspection doors and door frames are invariably made of hematite iron. The door-lifting gear may be of the balance-weight type or fitted with pneumatic or hydraulic cylinders or hand winches, but the popular type is hydraulic, and as hydraulic pressure is usually available for the tilting cylinders it is preferable. Although sometimes water-cooling is adopted in very active mixers for the chills between the port ends and the mixer, the usual practice is solid chills of cast steel or cast iron.

The mixer spout is made either of cast steel or built up of structural material. In either case it is designed so as to be easily renewable in case of mishap without having to disturb the body of the mixer.

Many forms of port ends for mixers and tilting steel furnaces are in vogue, and it is essential that these be portable—one of interest being that designed by Mr. E. D. Morgan, one of the members of this Institution. This consists of quarter-angle bends forming the gas and air connections between the mixer body and the regenerators. These bends are easily handled by the overhead crane, and if a spare set is kept ready they can be quickly changed in case of need, saving time involved in repairing the ordinary type. No pull-back gear is necessary with this type of port end. In practice the most usual form of port end is of box section, with the gas and air passages built up of brickwork inside. These port ends are movable, and are carried on wheels, and pull-back gear is provided, usually operated by hydraulic cylinders but sometimes by hand gear.

Tilting Steel Furnaces.

The first tilting furnace introduced into this country was on the Talbot process at the works of the Frodingham Iron & Steel Company in the year 1901; since then a large number of works have adopted this process. The two largest installations are those at the works of the Cargo Fleet Iron Company and the South Durham Steel & Iron Company. The furnaces at these plants are each of 175 to 200 tons' capacity, being 55 ft. long by 24 ft. wide. They are each carried on three stands, fitted on the top side with cast-steel toothed rack plates on which the furnace rolls, the operation being performed by means of hydraulic cylinders exactly as

* Abstract of Paper read, January 21, before the Cleveland Institution of Engineers.

in the case of the mixers before described. The bodies of the furnaces are built entirely of structural steel, the plates being 1¼ in. thick, with channels of 15-in. by 4-in. section strengthening the sides, the flat bottom being strengthened by means of 18-in. by 7-in. joists.

The design of steel furnaces differs from that of the mixers inasmuch as they are made of rectangular form, which is more suitable for the greater bath area. Although most of the Talbot steel furnaces at work in this country are made to roll on racks, a number are tilted on rollers similar to the method adopted for mixers. A Talbot furnace of this type of 275 tons' capacity is installed at the works of the Skinningrove Iron Company. It is 54 ft. long and 21 ft. wide, and is carried on twelve rollers on three rockers at 17 ft. 6 in. centres.

Although the Talbot process of tilting furnace has found such favour in this country, the Wellman type, introduced by Messrs. Wellman, Seaver & Head, Limited, is also being installed. One of the earliest of this type of tilting steel furnaces fitted in this country was one of 40 tons' capacity at the works of Messrs. Alfred Hickman, Limited, Bilston. This furnace, which is 37 ft. long and 19 ft. wide, is probably unique, so far as this country is concerned, inasmuch as it is tilted by means of electric power. The motor operating the tilting gear is of 75 h.p. running at 580 r.p.m. This is reduced by means of reduction gear of a ratio of 40 to 1, and further reduced by spur wheel and pinion of a ratio of 6 to 1, bringing down the speed of the pinions gearing with the racks on the tilting rods to about 2½ r.p.m. It was found that, when pouring, the peak load on the motor was 50 h.p., whereas on bringing the furnace back to its normal position the peak was nearly 100 h.p. The arrangements and details of the roller gear are the same as in mixers.

As the temperatures in steel furnaces are so much higher than in mixers, the body of the furnace has to be built proportionately stronger to withstand the extra expansion. In the Wellman design the ends are made of box section bound longitudinally by strong girders fitted at the sides of the furnace top and bottom, with longitudinal stays on the top. I understand the Cargo Fleet Iron Company have recently designed and put in commission a Talbot furnace based on their experience, particulars of which would be of interest.

Although little is done in the way of water-cooling the parts of a mixer, the doors, door frames and chills between the furnace and port ends are water-cooled on steel furnaces. Moreover, water-cooled seals are usually fitted between the port ends and regenerators. This is essential to prevent the leakage of gas at the connecting point between the port end and the uptake, although sometimes, as in the case of some mixers, this takes the form of a sand seal. As in the case of mixers, the port end is usually arranged to move endways, either by hydraulic cylinders or motor or hand gear. This is convenient for repairs, and for experimenting to find the position for the port nose and the shape of passages to give the best results. The channels over the roof are also water-cooled in some instances. In isolated cases, instead of these means for moving the port ends being adopted, they are moved by means of an overhead crane, but seeing that the port-end block of a large furnace may weigh upwards of 50 tons, it is no small matter to fit a crane of this capacity unless it is also required for some other purpose.

As regards the chills between the port ends and furnace, although these have been made of hematite iron with the water-cooling pipes cast in, they do not last very long, but this type of chill is often adopted for fitting between the port end and uptake. For the former the chills are usually made of forged-steel billets, which are bored for water-cooling and jointed together at the ends by bolts. The Cargo Fleet Iron Company have designed an efficient chill for this purpose.

Lifting cylinders are often fitted to the port ends to clear the seals between the uptake and port end before they can be moved horizontally; it is, however, possible to avoid this by fitting detachable seals.

Discussion.

Mr. Thos. Twynam (Cargo Fleet) thought that possibly Mr. Jackson had not sufficiently emphasised the difference between the Skinningrove and the Cargo Fleet mixers, the one being centrally tilted and the other rolling forward. It was a question whether it really paid to put down these very large active mixers. If they had the blast furnace to make the pig-iron, it was there that they should make it suitable for steel-making purposes. It seemed to him a very expensive method to put in these active mixers when, if the pig-iron was fairly suitable, it could be carried direct from the storage mixer to the steel furnace. Referring to water cooling, Mr. Twynam added that at his works they had water pipes right across the brickwork, and the arrangement answered very well indeed, effecting a great saving.

Mr. S. Worton took exception to Mr. Twynam's views as to the necessity of the active mixer. Particularly in the Cleveland district, where they were making basic iron from very unsatisfactory material, an active mixer was found to be essential.

Mr. E. Crowe alluded to a "vital difference" in the Talbot furnaces at West Hartlepool, which he said were open-ended. They had a block inside the furnace so that the intense heat of the bath was not on the working joint of the furnace.

Mr. A. Waterfall said he was in charge of two 400-ton mixers at the North-Eastern Steel Works, which had been there nine years and had proved very satisfactory. They were mixing anything from 1,000 to 1,200 tons of iron and scrap per week. At first the seals were water-cooled, but they gave a lot of trouble and were done away with.

Mr. G. Harrison (the President) remarked that where water-cooling could be done away with it meant a considerable saving. Where a furnace rolled on rollers there was a considerable amount of sliding surface, whereas in the case of a furnace rolling on a horizontal path, all that rolling surface, which was liable to become foul and gritty, was done away with. That he thought should make towards lower cost of upkeep. It seemed to him that electricity was very suitable for tilting purpose, as it got rid of the uncertainty of the hydraulic ram.

Mr. Jackson, replying, agreed with the President as to the suitability of electricity for tilting, and said he had been at a loss to understand why it had not been adopted more generally in view of its adaptability. At the same time he thought there was no difficulty in designing a satisfactory hydraulic piston, and added that the design in vogue at Skinningrove was very efficient. Answering a question as to the total weight of a mixer, he said that in the case of a 400-ton mixer it meant that with contents, etc., they probably had to tilt somewhere in the neighbourhood of 1,000 tons.

The business of Mr. J. Wilde, engineer and merchant, and that of the late Mr. H. Wilde have been amalgamated, and will in future be carried on at Finsbury Pavement House, London, E.C.2., as John Wilde & Sons.

Further Notes on Aluminium Castings.*

By James Gaunt.

Following on the writer's previous Paper on the "Production of Aluminium Castings," which was intended to emphasise the fundamental principles underlying the making of moulds for aluminium castings, the present Paper is intended to carry the subject a little farther by reference to the treatment of the metal during and after melting.

In attempting to do this in a manner which I hope will appeal to the practical man, I shall, of necessity, appear to encroach on the ground covered by others, but the excuse must be—if any excuse be necessary—that the whole of the present Paper is the result of the author's personal experience. Though many of the points raised could be carried farther into the field of scientific research, the intention is to keep within due limits, so as to be understood by all; and this involves no slur on the mental capacity of foundrymen. In no branch of modern engineering is there more call for highly-trained powers of observation and deduction, and in which individual application is more pronounced.

In the casting of aluminium is got a total reversal of all that holds good with other non-ferrous alloys, and more especially is this the case in regard to pouring temperatures. With almost all other alloys there is a point midway between two extremes, where the best results are obtained in regard to soundness and strength. With aluminium the only successful pouring temperature is that as little above the melting point of the alloy as is consistent with the obtaining of a fully-run mould. That is to say, it should be poured as cold as possible.

Here a word of caution must be introduced. Although the aim should be not to overheat the metal, it must be remembered that all metals which are being introduced into the aluminium in order to form an alloy, and especially those whose melting point is higher than that of aluminium, must be first brought into a state in which they can be readily assimilated by the molten aluminium. This result can be attained by first making an alloy or hardener of the aluminium and the metal to be introduced, such as the 50-copper 50-aluminium; otherwise the metals must be thoroughly stirred in to get them to mix intimately.

As an instance, zinc can be alloyed direct with aluminium, but unless it is thoroughly mixed trouble often arises in heavy castings through the separation of crystals high in zinc in the bottom of the castings; or in the case of small castings through the last one or two of a cast coming out very brittle owing to the heavier constituents settling to the bottom of the crucible, giving a richer alloy. This is easily realised when it is remembered how brittle the high-copper alloys are, especially the notable half-copper half-aluminium. Thorough stirring in any case is something to the good, and should never be omitted.

Coming back to the statement that aluminium should be poured at as low a temperature as possible, this naturally brings us to a question often haphazardly answered—What is the pouring temperature for aluminium?

As in the trade the term aluminium covers scores of alloys of very varied composition as well as pure aluminium itself, many disputes arise between founders on this question. One may claim to cast at 40-50 deg. higher or lower than another, and yet each may be obtaining the best possible results. Thus the statement as to what one person has found by experience to be a suitable standard should always be accompanied by a qualification stating the composition of the alloy referred to. Thus a suitable temperature for 92-aluminium and 8-copper may be taken as being 1,260 deg. F., but an alloy of 85-aluminium, 10-zinc and 5-copper will cast best at 1,225 deg. F. Even so, these are not fixed and immovable standards for the production of castings. They may be for the casting of test bars, but often casting to obtain the best results on a test bar means sacrificing the soundness or other quality in the casting.

Castings vary in thickness, in design, in the physical standards they have to meet, but in the majority of cases the necessary variations in casting temperature are due to variations in the thickness, and should be kept within such limits as just enable the mould to fill properly and avoid non-runners.

In order to demonstrate the effect of temperature on aluminium alloys a series of experiments

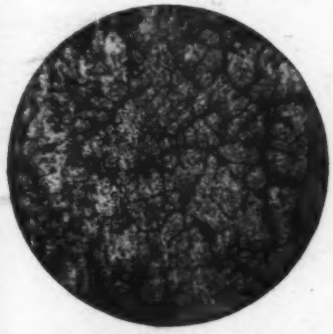


FIG. 1.—92 COPPER, 8 ALUMINIUM, CAST AT 1,260 DEG. F.

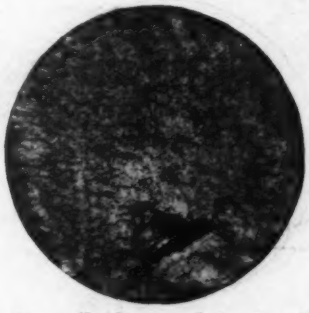


FIG. 2.—92 COPPER, 8 ALUMINIUM, CAST AT 1,700 DEG. F

FIG. 3.—5 COPPER, 10 ZINC, 85 ALUMINIUM, CAST AT 1,260 DEG. F.

* Paper read before the London Branch of the British Foundrymen's Association, March, 1918.

was conducted to show what happened under varied thermal treatment. These experiments related chiefly to such variations as are met with in the foundry in melting and casting, and did not cover any effects which might be obtained by annealing. From them it appears that the copper-aluminium alloys are most susceptible to overheating and beyond 1,500 deg. F. the deterioration is most marked.

Figs. 1 and 2 show a 92-copper 8-aluminium cast at 1,260 deg., 1,500 deg. and 1,700 deg. F. Fig. 1 (No. 1) shows a typical binary alloy with a background of aluminium in which are standing in relief crystals of a copper-aluminium compound. Close examination fails to show any tendency towards sponginess, and the whole is a well-knit structure and gave 9.5 tons tensile.

No. 2 (not reproduced) which was cast at 1,500 deg., also appeared to have a good structure, but the lines ran straighter across the face, cutting up the matrix of aluminium into a finer state, which reduced the tenacity of the metal.

In No. 3 (Fig. 2), cast at 1,700 deg. F., the structure appears to have broken down completely, and the straightness of the lines appears to have developed to the full. A curious feature here shows itself in the parallel lines of the copper-aluminium portion, which was to some extent foreing. No. 11 (Fig. 8) was overheated, cooled, and then fluxed. The hole shown in the centre is due to a "blow." The rest of the metal shows a much better structure. Evidently the flux added after cooling is much more effective.

No. 12 (Fig. 9) is the same—aluminium 85, copper 5, zinc 10, to which has been added a little tin. This gives an alloy suitable for work which has to stand water-pressure tests, and it will be noted that the structure is quite good. One notable point in these alloys is that in the course of many tests I have never obtained the full percentage of tin in the alloy, which the amount of tin added would lead one to expect. Thus, in this instance, 1 per cent. was added, and in the analysis of the alloy only 0.38 per cent. was found. Additions of tin, however, render the metal very brittle, so that its use will not be popular where strength is required.

No. 13 was very similar to No. 12, but in this case lead was added. The results were very similar, except that the alloy was not so closely crystalline.

Fig. 10 (No. 14) is an alloy of Cu 5, Zn 7, Al 88, cast at 1,280 deg. F., and is a normally constituted specimen. This is merely shown as a contrast to No. 15 (Fig. 11). After casting with the result shown in No. 14 the metal was put back into the furnace and maintained at 1,500 deg. F. for four

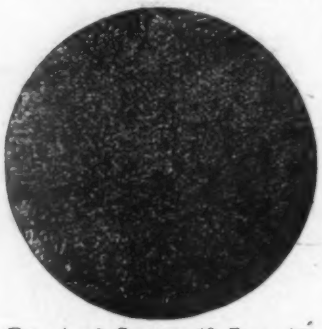


FIG. 4.—5 COPPER, 10 ZINC, 85 ALUMINIUM, CAST AT 1,500 DEG. F.

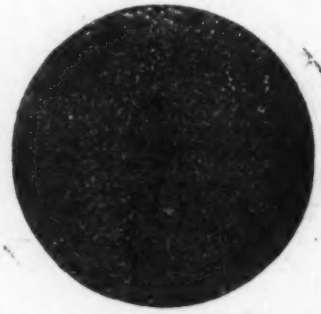


FIG. 5.—5 COPPER, 10 ZINC, 85 ALUMINIUM, CAST AT 1,225 DEG. F. UNFLUXED.

FIG. 6.—ALLOY OVERHEATED AND UNFLUXED, SHOWING POROSITY.

casted in No. 2. Blowholes are scattered over the mass of the metal, one of which is shown, and the whole structure of the metal is very open. As a comparison a reference to Fig. 1 is very interesting. The tensile of No. 3 was only 7.2 tons.

Fig. 3 (No. 4) is a 5-copper, 10-zinc and 85-aluminium alloy, cast at 1,260 deg. F., and shows a good structure. Fig. 4 (No. 5) is the same mixture cast at 1,500 deg. F., and betrays symptoms of sponginess. In No. 6, which was the same alloy but cast at 1,700 deg. F., the metal was very porous. For No. 7 the same alloy was cast at 1,225 deg. F. No. 4, cast at 1,260 deg. F., gave 8.48 tons tensile, and No. 7, cast at 1,225 deg. F., gave 9.68 tons tensile.

No. 8 (Fig. 5) is the same mixture once more cast at 1,225 deg. F., but unfluxed, and shows a distinct porosity throughout. No. 9 (Fig. 6), overheated and unfluxed, shows that the porosity is very much aggravated by overheating in spite of subsequent cooling down, without fluxing.

No. 10 (Fig. 7), overheated and fluxed, still retains some porous patches in spite of fluxing, due no doubt to the metal being fluxed whilst hot, and some further oxidation taking place during cool-

hours, with the result shown in Fig. 11. Here the whole structure is completely altered, and only a porous mass of metal is the result. One point is, however, of vital interest, and that is a comparison of the analyses of the metal before and after overheating:—

Before.		After.	
Cu	4.71	Cu	7.65
Zn	7.2	Zn	14.88
Fe	0.56	Fe	0.5
Si	0.46	Si	0.61
Al	87.07	Al	76.36

Here again an interesting negative result was obtained, much to our surprise. The metal had been melted in a plumbago crucible, and as this method is often condemned because of ill results due to carbon absorption, it was expected that we should find an appreciable amount of carbon. But in spite of all efforts we were unable to obtain any evidence of its presence.

In No. 16 sulphur was added in the form of flowers of sulphur. The metal had a good white appearance and cast very well indeed, and a little research along these lines seems to suggest the possibility of good results.

Fig. 12 (No. 17) shows the effect of the addition of a high percentage of tin. In this sample there is 4.17 per cent. The tin evidently liquates out, filling in all around the crystals of the alloy; or, perhaps, a better theory would be that it is some eutectic of aluminium and tin of a very brittle nature, as the strength of the alloy is completely destroyed by its presence.

A series of experiments was made using manganese dioxide (0.08 per cent. Mn.) added to the metal along with a flux, but the experiments have not reached a stage to afford reliable evidence of the effects.

No. 19 was a chill-cast, overheated metal, and showed a very finely-divided structure, where the ills found in sand-cast overheated metal seemed to have disappeared.

All the foregoing slides are of 150 diameters magnification, and are etched with a 10 per cent. solution of caustic soda.

From the foregoing, it will be seen that in all cases high temperatures are fatal to the making of aluminium castings, although certain more or less successful methods can be adopted to overcome the defects. Efficient fluxing and chilling are the best methods, but in every instance the metal must be cooled before pouring. Cooling should always precede fluxing, and the fluxing should be done immediately before pouring.

Chilling should never be taken to mean quenching in water, the hydrogen liberated by quenching having a very bad effect on the metal.

The amount of any flux used to remove all traces of oxidation will vary acccording to the amount of overheating, and the length of time which the metal has been kept in the overheated state. Aluminium has a very high affinity for oxygen, and this affinity is aggravated by higher temperatures. It should also be remembered that all the oxide is not visible on the surface, owing to the similarity of the specific gravity of the oxide to that of aluminium. It may therefore be accepted as a good general rule that more flux is required to efficiently scour an overheated metal than the quantity usually used on normally treated metal; also that metal fluxed whilst still at a high temperature is more than likely to be reoxidised to some extent during cooling, and therefore the best method to adopt is to cool the metal first, and then flux.

Fluxes in common use are zinc chloride (perhaps the most active), ammonium chloride, or sal ammoniac (a slowly active body), and common salt. Personally, the writer has yet to meet the flux that can equal zinc chloride.

There is still, however, a very serious aspect of overheating which cannot be overcome, and that is loss of aluminium. The figures given in respect to specimens 14 and 15 in regard to the increase of copper and zinc illustrate this. The increase is simply due to the loss of aluminium through oxidation, which means that the copper and zinc increase according to the loss. In this sense overheating is a very serious matter, which, when accompanied by soaking, is doubly aggravated by the extreme rottenness of the resulting metal.

Discussion.

Mr. Pitts asked if the author had ever obtained the results which the A.I.D. asked for, and if so would he say how?

Mr. T. H. Barker said he had obtained most varied results with 85-aluminium, 2½-zinc, and 2½-copper, using chill-cast test bars. Then tensile varied from 8.4 tons to 15.2 tons on bars made, so far as he could tell, under precisely the same conditions.

Mr. Gaunt said he had not had any work to do for the A.I.D., but he knew the results they asked for were extremely difficult to obtain. He had been given a hint, however, that, it was suggested, helped in this direction, although he had not been able to try it. It was to use from 5 to 15 per cent. of cupro-manganese in making up the hardener in place of part of the copper. It was said to overcome the difficulty. He had no doubt that a lot of the trouble was due to overheating in melting. Even the smallest differences in the casting temperature and the melting temperature gave big differences in the tensile results. It was necessary to handle the melt very carefully and to flux it very efficiently. Aluminium alloys were totally unlike alloys of other metals, because the specific gravity was so low, and any oxide formed might mix intimately with the metal, whereas the oxides of other metals were usually much lighter than the metal itself, and rose to the surface.

Mr. Barker asked whether in casting test bars the temperature of the chill itself had any effect.

Mr. Gaunt said the temperature was bound to have a certain effect, because a hot chill would not chill so quickly as a cold one. On the other hand, if the metal was poured into a dead-cold chill the structure of the metal would be destroyed.

Mr. Pitt remarked that the A.I.D. was asking

Fig. 7.—Alloy Overheated and Fluxed whilst Hot; showing Porous Patches.

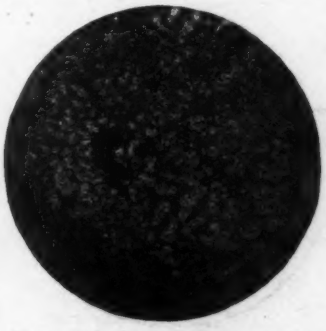


Fig. 8.—Alloy Overheated, Cooled and Fluxed; showing Better Structure.

Fig. 9.—5 Copper, 10 Zinc, 85 Aluminium, with a little Tin.

for something like 11 tons, and he would like to know the best results that Mr. Gaunt had obtained.

Mr. Gaunt said that his tests were all on sand-cast bars, and the highest figure obtained from them was 9.68 tons.

Mr. Sydney Cleaver said the A.I.D. allowed up to 14.5 zinc, and it seemed from his experience that the nearer they got to that figure the better the results on the test bar. He introduced the copper as a 50:50 hardener alloy and used the purest form of commercial aluminium obtained from the British Aluminium Company, and by adding the hardener and then the zinc sound bars were obtained varying from 9 up to 12 tons. So long as the temperature was from 625 to 650 deg. C., which was equivalent to Mr. Gaunt's 1,225 deg. F., a standard bar could be obtained which would give from 10 to 11 tons. The temperature seemed to be the dominating factor, and if the actual heating of the metal was between 750 and 800 deg. C., equal to Mr. Gaunt's 1,500 deg. F., results up to 12 tons could be obtained.

Mr. Gaunt replied that above 1,500 deg. F. all the experiments showed that the metal was absolutely ruined as regards structure.

Mr. Pitt asked Mr. Cleaver whether in increasing the spelter or zinc as he had suggested he sacrificed the elongation.

Mr. Cleaver said he mostly found that with a 10-ton tensile 4 per cent. elongation was obtained. Although on the L5 specification the A.I.D. asked for 11 tons from a chill-cast bar, they would take 8 tons from a sand casting, and there was no trouble in getting well over 8 tons every time in sand castings so long as the temperature was watched.

Mr. Richardson said he had just had two rejections at 8 tons. He had introduced manganese, as Mr. Gaunt had suggested, in the shape of manganese zinc, but he could not say he had noticed any great benefit, although the results were very consistent. The A.I.D. people were kind enough to let him cast aluminium bars into an open chill, and that gave the most satisfactory result so far as consistency was concerned. There was shrinkage along the whole length of the bar, but that was cancelled with a fairly generous allowance on the top, so that all the shrinkage took place on the top, the part which was cut off. Whilst agreeing that temperature was a fundamental factor to success, one of the most important points was the purity of the spelter. If he got 99.9 per cent. spelter he found his tests came out consistently at 11 to 12 tons with the full elongation. He had even gone up to 7 per cent. elongation, although that was exceptional.

Mr. Gaunt, referring to the purity of spelter, said that a high price had to be paid for 99.9 per cent. purity. His specimens were obtained with ordinary commercial re-melted spelter, and in the case of No. 1 the tensile was 9.5 tons—that was a sand casting—and in the case of 5 per cent. copper and 10 per cent. zinc the figure was 9.68. Those were fairly satisfactory results without going to the expense of paying £90 per ton for spelter.

Mr. Ellis asked if any other members had had the same experience as the author with regard to alloys of tin. It was something new to him. According to the Paper there was a considerable loss of tin on analysis, and his experience did not confirm this.

Mr. T. H. Barker asked at what temperature did aluminium start to deteriorate in the overheating.

Mr. Gaunt said there was hardly a definite temperature at which aluminium appeared to deteriorate. It depended on the alloy. A 92:8 aluminium-copper alloy would start to deteriorate at below 1,500 deg. F., whereas one containing zinc would stand that temperature without very much apparent deterioration. Special alloys containing more than 90 per cent. aluminium seemed to begin to deteriorate at about 1,300 deg. F., and above 1,500 deg. the deterioration was very rapid.

Fig. 10.—5 Copper, 7 Zinc, 88 Aluminium, Cast at 1,280 Deg. F.

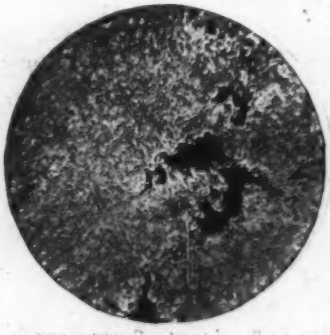


Fig. 11.—Same Alloy as Fig. 10, Maintained at 1,500 Deg. F. for 4 Hours.

Fig. 12.—Showing Effect of Addition of 4.17 per cent. of Tin.

Mr. Richardson asked if any tests had been carried out on the introduction of a small amount of phosphorus in aluminium alloys. It had been suggested to him, but he confessed he knew nothing about it.

Mr. Gaunt said he had no experience of the introduction of phosphorus into aluminium alloys, although in making up solders for use with aluminium the introduction of phosphorus was a very good thing. He used one of this nature, and could only attribute its success to the fact that the phosphorus acted as a sort of flux on the aluminium oxide formed on the surface of the metal and helped to bring the two metals into closer contact, in the same way that zinc chloride helped in the soldering of brass. Aluminium had a high affinity for oxygen, and something was necessary to be used which would rob the aluminium of its oxygen. Judging from the results

of the solder, he should say that phosphorus had quite a good claim in regard to being used as a de-oxidiser of aluminium, although personally he had never tried it.

MR. ELLIS said he had carried out an elaborate series of tests to see if phosphorus would be of any advantage if added to aluminium-copper-zinc alloys, but found that the advantage was not very marked. In regard to the author's slides of overheated specimens, he did not think aluminium deteriorated to anything like the extent that was imagined, provided the alloy was allowed to cool down to its correct casting temperature. The mistake usually made was that the metal was poured at a higher temperature than it should be.

MR. GAUNT said that in all the experiments he had described the metal was melted separately for each individual bar. In some instances the metal was overheated and cooled down and cast at normal temperature, and there were certainly signs of deterioration, except in the case of one which was overheated and cooled down to normal temperature before pouring and fluxed when it became cool. One he fluxed whilst it was overheated, and that was spongy, whilst another which was cooled before it was fluxed gave a sound casting.

MR. T. H. BARKER asked Mr. Gaunt if he used anything to dress his chills.

MR. GAUNT said he did not. He had found that new chills were apt to blow, and the only treatment then that he gave them was to throw them on the stove floor, and give them a thorough heating up to redness before using them. He used different varieties of chills—of cast iron and aluminium and sometimes gunmetal. Altogether, he thought he got the best results from cast iron. Aluminium soon lost heat and accepted any deposit of moisture that might be thrown up into the mould. The same applied to brass and gunmetal chills; they, too, readily parted with their heat, and if the moulds stood over for any length of time they became damp. An iron chill held the heat longer and prevented the deposit of moisture.

MR. T. H. BARKER said he had used gunmetal chills without successful results.

MR. GAUNT said it all depended on the sand that was used. His work was nearly all machine moulding, and the sand was used over and over again during the course of the day. It was put into the moulds almost steaming. That had a tendency to throw damp on to the chills. If they were working with cold sand it was a different thing, but he was forced to use sand over and over again, and except the first thing in the morning it was always steaming. He got some trouble with aluminium and brass or gunmetal chills, but very little with cast iron, probably because he kept his sand on the dry side. If there was too much moisture in the sand there was the possibility of not being able to get a casting out at all; the whole thing was just two surfaces filled in with air. It looked all right when taken out of the sand, but if they excavated a little bit with a file it would be found that the casting was practically hollow right through.

MR. RICHARDSON mentioned that he had obtained some fair results with cast iron, casting vertically.

MR. GAUNT doubted whether any great benefit was to be obtained in this way, because in the case of heavier metals there was a certain compression of the molecules due to head pressure, but with aluminium there was very little head pressure, and no benefit would be obtained from casting vertically unless the head was carried up to 6 ft. or 7 ft.

MR. SYDNEY CLEAVER said he had obtained his best results by casting horizontally without a riser, and just cupping up above the mould.

THE CHAIRMAN said he only used aluminium when he was obliged to for patterns, and one question which was very vague to him was whether aluminium really alloyed with other metals freely, or whether it merely mixed. If some of the metals fell to the bottom, then it could not really be called an alloy; it was only a mixture.

MR. GAUNT said that in replying to that he would have to rely on experiments carried out by other people. Aluminium did not alloy readily with any metal, but with aluminium and zinc there was a certain amount of alloying. Certainly, however, aluminium did not alloy with other metals to the extent that other metals alloyed with each other. As to rate of pouring, his experience was that in order to get the best results it was necessary to cast at as low a temperature as possible—that meant making the runners as big as possible—and "bunging it in," otherwise it would be necessary to overheat the metal in order to make it run.

MR. T. H. BARKER said that working with 25 per cent. zinc, which he admitted was very heavy, when casting at as low a temperature as possible the casting was full of blow holes. If cast a little hotter they were fairly sound.

MR. GAUNT said the alloys he had dealt with in the Paper did not run above 15 per cent. of other metals. That was about the limit for ordinary commercial alloys. With a special alloy like that mentioned by Mr. Barker it would be necessary to find the best pouring temperature.

MR. E. J. DAVIS said it was an extraordinarily difficult thing to polish aluminium without pulling out some of the hardened constituent. Therefore it would be interesting to know whether certain features of the author's micro-photographs were porosity or holes made in polishing. How did the author distinguish between blow holes and holes caused in polishing?

MR. GAUNT said the reason why he concluded the holes he had referred to were blow holes was because they showed on the outer surface whilst the rest of the casting showed sound metal. He had examined the specimens with a low-powered glass, and had no hesitation in saying that the holes were blows. They had all been finished off with a chamois leather.

MR. BARRETT, referring to pouring, said that in certain cases to pour as quickly as possible would set up films of oxide in the runners which might pass into the casting. He preferred to pour in a steady stream, not slowly, but quickly enough for it to swill all round the cup.

MR. PITT asked if the author found he got better results in pouring his test bars to shape, or with a notched bar turned to shape.

MR. GAUNT said with normally poured aluminium there was no very great difference in the results. The reason for casting to shape was that the metal section of the bar gave a suitable size of specimen which was cast under exactly the same conditions as the test bar which was to be pulled. Otherwise he would have cast one-inch bars.

MR. STONE said that pouring as quickly as possible with small castings was all right, but when it

came to a casting 4 ft. long, 15 in. deep, and 4 ft. 6 in. wide, would Mr. Gaunt throw the metal in in the way he had suggested, or would he govern it by the downstick of the runner? Which was the better?

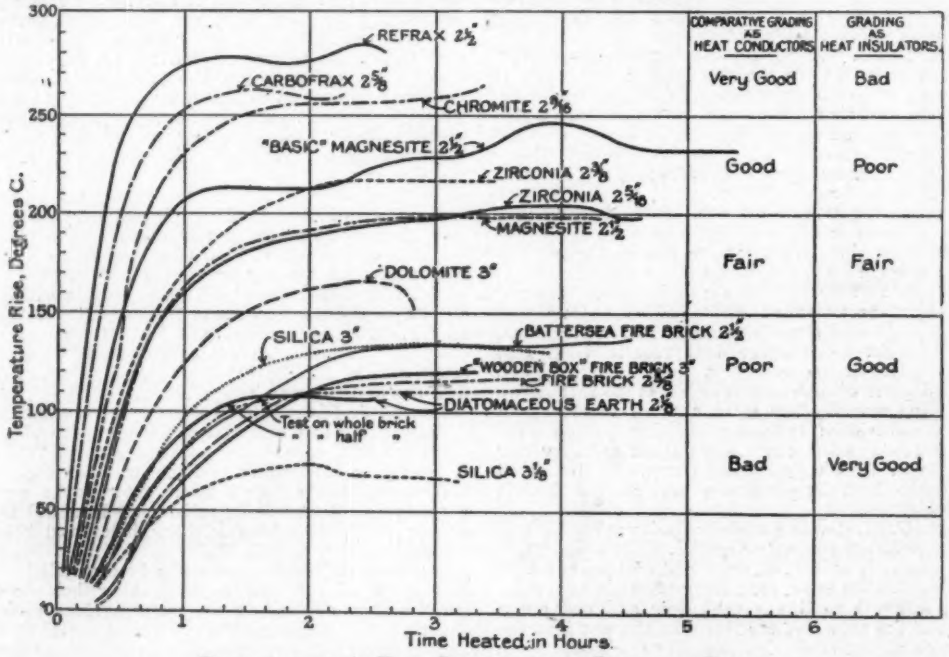
Mr. Gaunt said that with large castings, not perhaps so large as those mentioned, but castings for the oil sumps of motor cars, he got the best results by having the down runner as large as possible and getting the metal in as quickly as he could. Otherwise it was impossible to get the metal running over the whole of the surface. Personally, he always advised running an aluminium casting as quickly as ever it was possible to do it, and having no obstruction in the way of the aluminium entering the mould.

Mr. Stone said his point was that with a large area covered with aluminium with, say, a series of brackets or bosses, if the metal were poured too quickly there would be unequal contraction, and there would be porosity all the way round, whereas if they governed by the downstick got fairly smooth surfaces.

Mr. Gaunt said that his usual practice in the case of heavy bosses connected up to thin sections was to place the runner as far away from the bosses as possible and to do away with any riser on these bosses. In this way the metal passed through the thin section and lost some of its heat before entering the heavy section of the casting. That very often would give the result which he presumed Mr. Stone obtained by running castings slowly. It was necessary to pour at a temperature at which they could get the casting to run, but it was not a bad plan to run first into the thinnest part and let the metal rise up into the thickest part and at the same time run as quickly as possible. If they could get the castings without a riser it was always best to do so, because the addition of the riser tended to throw the heat into a spot which was already aggravated by reason of the heavier section. It was not, however, always possible to do that. He had found by experience that there was usually a certain place where a runner could be put which gave far better results than at other points, and he preferred leaving castings even with hard sand cores in the mould until they were absolutely cold before taking them out when once the proper position of the runner was found. In that way he did not experience any trouble due to contraction stresses.

Mr. Davis asked the author's opinion as to the best method for taking temperatures.

Mr. Gaunt said he thought the best method with aluminium was the direct insertion of a thermo-couple into the metal without any covering. An iron-constantan couple gave quite a reasonable life before it was worn out.



Diagram, showing Heat Conductivity of Refractory Bricks.

Heat Conductivity of Refractory Bricks.

In the course of his address to the Society of British Gas Industries on April 18 the retiring President (Sir Robt. Hadfield) said that in view of the important work carried out by the Society in the past in connection with refractories, members would probably be interested to see some results of experiments that had been carried out at his company's works on refractory bricks of different types. He had embodied the results in a diagram (reproduced herewith). The experiments comprised bricks known as:—(1) Refrax; (2) Carbofrax; (3) Chromite; (4) "Basic" Magnesite; (5) Zirconia; (6) Magnesite; (7) Dolomite; (8) Silica; (9) "Wooden Box" Firebrick; (10) Diatomaceous Earth. The subject is of considerable interest to all who use refractories in furnaces where high temperatures are employed.

Some Continental Testing Machines.*

By H. S. Primrose, M.I.M., and J. S. Glen Primrose, A.R.T.C.

Tensile Testing Machines.—Whilst for a long time we have been almost exclusively confined to the use of lever testing machines in this country, their use has been almost entirely abandoned on the Continent, and also to a large extent in America. The hydraulic method of applying the load is nearly universal, but in most cases an independent system of measuring the stress is necessary, and few rely wholly upon the simple pressure gauge method for accuracy and continued reliability. Only one class of machine is so designed that the application of the load and its simultaneous measurement is accomplished by the same pressure system, and this, of course, constitutes a very simple, convenient and compact machine, which

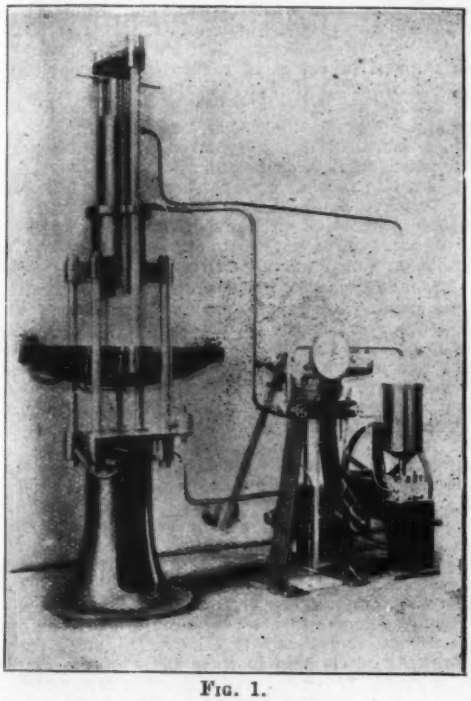


FIG. 1.

has no knife edges or springs to go wrong, and is further entirely free from inertia effects which are so fruitful a source of error. This principle is adapted to the vertical form of testing machine by Messrs. Amsler Brothers, of Switzerland, and their combination of press and pendulum gauge is recognised by the Association for Testing Materials as universal, and is constructed in a variety of sizes and standard forms. Their 1916 model of a 30-ton universal testing machine is shown in Fig. 1, and this has the various arrangements whereby round, flat and headed test bars may be tested in tension, enables bending, transverse and compression tests to be performed, and by means of easily adjusted bolsters it permits hardness, shearing, or punching tests to be made with the minimum of trouble.

The entire machine comprises three parts, the first of which is the press with a steel ram operated by compressed oil. The fit in the cylinder is sliding, so that friction is negligible owing to the small constant stream of oil escaping while the machine is at work. The pressure of oil is conveyed from the ram through a cross head with a hardened-steel socket to two steel bars freely supporting the cradle or moving head. The crown is secured to the base by four stout steel bars which support the superstructure, and these endure the maximum load of the machine without appreciable deformation. The base itself is a hollow iron casting with a steel table to anchor the wedge grips or other shackles, and no great strength is required in this stand as it supports no part of the loading, nor does it require to take any overhang, since the centre of gravity is not moved during the conduct of the tests. Tensile and shearing tests are made by securing the test bars between the base and the cradle, and compression, punching, bending and transverse tests are made between the cradle and the crown without any elaborate fittings. To raise the moving

TABLE I.—*Effect of Mechanical- and Heat-Treatment on Compression Strengths of Medium Carbon Steel, Cast-Iron, and Brass.*

0.45% carbon steel.		Compression yield point. Tons per sq. in.	Brinell hardness number. Kilos. per sq. mm.
Normal	Long.	47.5	185
"	Trans.	42.5	180
Single oil quenched	Long.	93.8	365
	Trans.	92.0	340
Single water quenched	Long.	91.0	340
	Trans.	89.5	340
Double oil quenched	Long.	85.3	320
	Trans.	82.5	320

Medium-carbon cast iron forged at 850° Cent.	Ultimate tensile strength.	Compression Elastic limit.	Ultimate crushing strength.	Reduction of length before cracking.	Brinell hardness number.
	Tons per sq. in.			Per cent.	Kilos per sq. mm.
1st Set. Water-cooled	12.5	30.2	59.8	26.8	165
2nd Set. Air-cooled	11.0	28.8	58.6	23.1	150

Beta brass for "A" metal, forged at 650° Cent. and air cooled.	Ultimate crushing strength.	Tensile tests				Brinell hardness number.
		Yield point.	Ultimate strength	Elon. on 2 in.	Reduction of area.	
	Tons per sq. in.			Per cent.		Kilos per sq. mm.
1st Set	62.7	22.6	40.2	23.1	22.3	170
2nd Set	61.0	21.2	39.4	21.5	25.0	165
3rd Set	59.8	20.6	39.8	23.1	23.9	165
4th Set	58.0	20.0	38.2	28.4	28.7	160

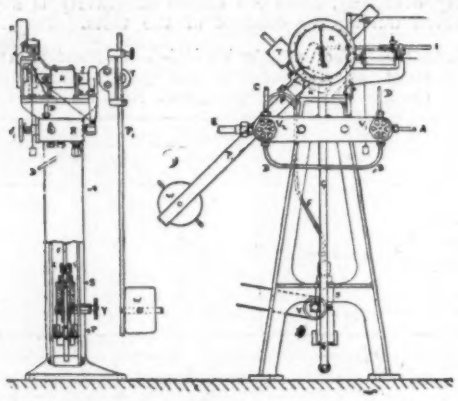
Values given are the average of four tests

* Abstract of Paper read, April 13, before the Staffordshire Iron and Steel Institute and British Foundrymen's Association. Mr. H. S. Primrose is Metallurgist to the National Forge and Foundry, Braintree, and Mr. J. S. Glen Primrose, Metallurgist to Messrs. Ransomes & Rapier, Ltd., Ipswich.

head to any required position the pressure oil is admitted by the valve at the right of the press, and to lower it again by gravity it is sufficient to open the release valve on the pressure gauge, and let the oil return to the reservoir in the pump.

The high-pressure oil pump is the second part of the apparatus, and it may be driven by either belt or motor. The oil supply is delivered by three pistons at a steady pressure up to three atmospheres, and the suction valves are controlled by a handle which lets the motor run light when in the "Off" position, but forces oil through the pipes when in the "On" position. If all other valves in the pressure gauge and press are closed, then the oil is simply short-circuited, by a spring-controlled valve, back into the reservoir.

The third part is a simple and accurate form of direct-acting pressure gauge or pendulum manometer, which measures the force exerted on the test piece by the oil pressure. This it does by displacing a freely hung pendulum from the vertical position so that the pointer of the gauge constantly indicates the force exerted by the automatic balance effected by the pendulum. Details of the pressure gauge and regulators are shown in Fig. 2. Pressure oil enters by pipe A, and may



be short-circuited by a spring at the back of the regulator R into the pipe B, and large return pipe C communicating with the oil reservoir. On opening the valve V_1, oil flows by the uptake pipe D to the cylinder of the press, and thus elevates the ram. The release valve V_2 on the left of the manometer puts the pressure pipe E into communication with the return pipe C. When load is placed on the specimen the oil pressure is conveyed by pipe F to the small cylinder S, which causes the piston P to move without friction due to its rotation and the slight escape of oil. The force which expels the piston P is transmitted to the two vertical rods G bolted together by a distance-piece at the bottom, and attached to a short block lever H at the top through ball bearings. The movement of H causes the shaft J mounted in the manometer frame with ball bearings to rotate and deflect the pendulum from its normal position till it assumes a position of equilibrium.

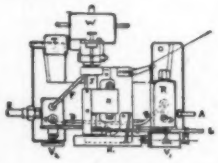


FIG. 2.

The pendulum rod can be suspended from several different points giving a variation in the sensitiveness of the machine.

Sensitive records of the variations in the loading of the test bar are secured in a unique manner. Attached to the front end of the rod J is a short steel arm parallel to the pendulum, and moving against a screwed rod L, which not only actuates the pointer moving over the scales of the dial K, but also carries a sliding pencil holder. The tracing pencil moves over the diagram paper clipped on to the brass drum, which rotates smoothly when actuated by the chord from the extensometer attached to the test bar. With short bars it is often sufficient to take the travel of the cradle relative to the base for commercial purposes, and this also saves the removal of the extensometer prior to rupture of the bar. When the bar breaks the pendulum falls back freely for but a short distance, as the oil escaping from the cylinder S has to do so by a small bye-pass so that the motion is comparatively slow and without jerk. Although the pressure gauge is so sensitive, there are no weak parts in it to go wrong, as it is throughout of the most robust construction, and yet it is not unwieldy. It simply requires to be bolted to the floor sufficiently level to let the pendulum swing in a perfectly vertical plane. The rotation of the screwed rod L, whilst holding the pencil carrier, enables the pointer to be readily adjusted to zero at any time. Measurements on the autograph diagram are facilitated, since the complete rotation of the pointer over the scale gives a travel of ten centimetres corresponding to the maximum load for each sensitiveness.

Other Tests.—To make transverse or bending tests, two roller supports are fixed at a convenient distance apart in the cradle by means of the side screws which engage the cross bars sliding in a slot which runs the full length of the cradle on each side. The middle support to apply the bending is suspended by a pin let into the side of the crown, and this only requires to be withdrawn to let it fit into a slot encircling the head of the support. This may be provided with a roller like the side bolsters, or it may be simply a rounded die to effect the bending test when the supports are moved into close proximity. The centrally held die may be provided with a spring clip holding a ten-millimetre ball to perform Brinell hardness tests when the cradle is raised with the specimen to effect the compression.

Compression tests are very simply made on test-pieces placed between two hardened steel discs, one of which is held in the middle of the cradle by a square foot-step, and the other is supported from the centre of the crown by a circular bolster provided with a spherical seating to ensure the crushing faces being parallel. Crushing tests are now more commonly specified than formerly, and interesting results are often obtained with metals which have been variously heat-treated and worked, as illustrated by Table I. The first section shows the toughening effect of oil quenching upon a medium carbon steel for power press screws, the second deals with the forging of ordinary cast-iron between dies in the press, and the third part shows how much even the strongest brass may be improved by mechanical treatment at the right temperature.

For making shearing tests, special yokes are fixed by the cross bolts through the base plate and the cradle. These two portions are provided with hardened steel cylinders with a hole through each

for carrying the test bar. Accurate alignment is secured by screwing up collars at the end, thus preventing any play between the shearing faces.

Punching tests as performed in the compression part of the testing machine only require a simple bolster to carry the punch and die in correct alignment, and to withdraw the punch without displacement of this after the flat test piece has been pierced. Several corresponding values of the ultimate tensile, punching and shear stress of several grades of steel are given in Table II., and show that simple relationships can be established between these values.

TABLE II.

Average tensile strength Tons per sq. in.	Actual punching stress. Tons per sq. in.	Shearing stress. Tons per sq. in.
21.3	18.3	10.1
25.0	19.2	11.8
28.1	21.5	12.9
32.0	23.7	14.3
34.5	25.5	15.2
39.0	28.0	16.8
43.0	30.7	18.0
47.5	34.1	19.6
"T"	0.65 T + 3.18	0.35 T + 3

Standardising.—Even although it is usual for each testing machine to be accurately calibrated by the makers and guaranteed to be correct, it is usually advisable to check them occasionally to ascertain if there is any variation during service. Messrs. Amsler have invented an ingenious standardising box which is light and easily handled. It can be used without expert knowledge to check testing machines either in tensile or compressive stress, both quickly and with as great exactness as by the dead load method.

As shown in section in Fig. 3, the box consists of a hollow cylinder of special steel filled with mercury which extends into a horizontal capillary glass tube projecting from the box. The tube is provided with a zero mark to which the mercury is adjusted by a micrometer screw, the stem of which projects into the enclosed space filled with mercury, and when the screw is advanced or withdrawn it pushes the mercury into the capillary or

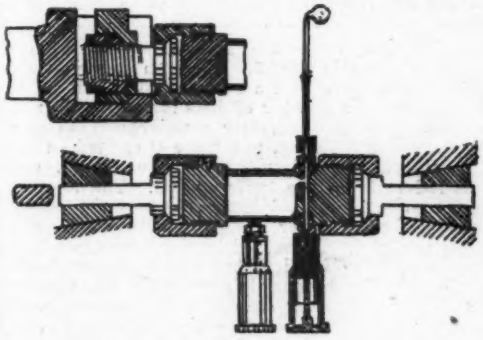


FIG. 3.

withdraws it into the box. When the hollow cylinder is stressed axially the volume decreases under the compression or increases under tension so that a volume of mercury equal to this volume change is expelled from or pulled into the box. Thus the micrometer handle must be turned to restore the mercury to the zero point in the capillary tube, the bulb at the end of which holds any excess and prevents its escape. The scale on the micrometer enables the observer to read hundredths of a turn of the handle, and this gives a measure of the change of volume of the steel cylinder, which, being thin walled to give large displacements of mercury, must not be stressed above its elastic limit. The extension boxes for tensile standardising have screw heads

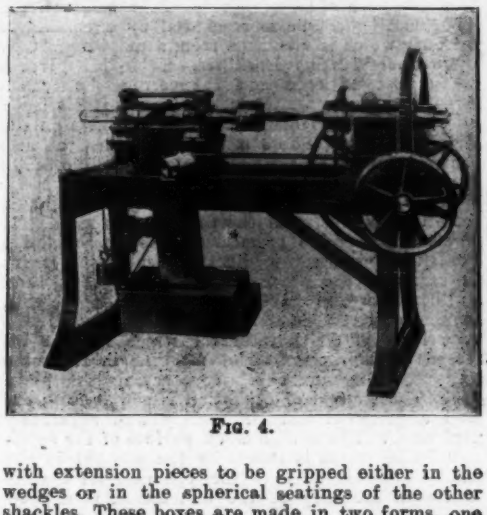


FIG. 4.

with extension pieces to be gripped either in the wedges or in the spherical seatings of the other shackles. These boxes are made in two forms, one for measuring compression only, and the other for either extension or compression, the former ranging up to 120 tons, the latter up to 30 tons.

Torsion Testing Machines.—The importance of this useful method of determining the shear strength of metals has been recognised only comparatively recently, and although many forms of lever machines have arrangements for carrying out this test and for measuring the torque, it is still not a common test to be made commercially. There is a simpler way of measuring the torque than by means of the customary lever. The balancing of the twisting couple produced lends itself readily to the use of the pendulum pressure gauge, and Messrs. Amsler make several types of machine in which this principle is used. The smaller hand size for torsion testing alone is illustrated in Fig. 4, which shows the machine to consist of a rigid frame with two heads, the fixed one for applying the torque, and the other moving on ball bearings and carrying the pendulum. The bar to be tested is screwed in jaws in the two heads, which take flat bars or rounded ones if provided with rectangular heads. The torsion couple is produced by a pulley driven by belt or worked by hand, and the rotation is transmitted to the test bar by worm and wheel. The pendulum, suspended from the moving head by an axis which rotates in ball bearings, serves to balance, by its inclination from the vertical position, the torque developed in the test bar. The weight of the pendulum bob is easily changed by removing parts of it which are bolted on, so that the sensitiveness of the machine can be increased by diminishing the maximum torque from the full 150 kg.-metres (say 1,100 ft.-lbs.) to 100 kg.-m. and to 50 kg.-m. The angular displacement of the pendulum in conjunction with the angle of twist of the test bar gives a means of autographically

drawing a diagram of the test. The movement of the pendulum-carrying head along the frame of the machine prevents the test bar from being subjected to the slightest tension as it shortens under the twisting it receives.

A more powerful machine capable of exerting torques up to 5,000 kg.-m. (say 17 ft.-tons) is made for testing transmission shafts. The couple in this case is exerted by an electric motor acting on the worm and wheel through a double train of wheels. The twisting couple is measured by a column of mercury which is displaced from a diaphragm box.

Hardness Testing Machines.—Table III. gives a useful list of equations connecting the tensile strength in tons per sq. in. of various steels, both alloy and plain carbon, with their hardness on the Brinell and the Shore scleroscope scales, as also the relation which exists between these two scales for the steels concerned.

Instead of the diameter, the size of which is sometimes doubtful in the case of soft metals, it is often preferable to measure the depth of the Brinell ball imprint to get the area of the cavity in terms of the product D.t. where D is the ball diameter and " t " the impression depth, both in millimetres. Messrs. Amsler Brothers have a neat form of depth indicator which may be inserted in their compression machine in the same way as the ordinary bolster carrying the plain ball. The method of operation is simple, and the zero adjustment can be quickly and accurately performed. The smooth metal surface of the specimen to be tested is raised by the support in the cradle until it engages the ten-millimetre steel ball, then the body of the instrument is slipped

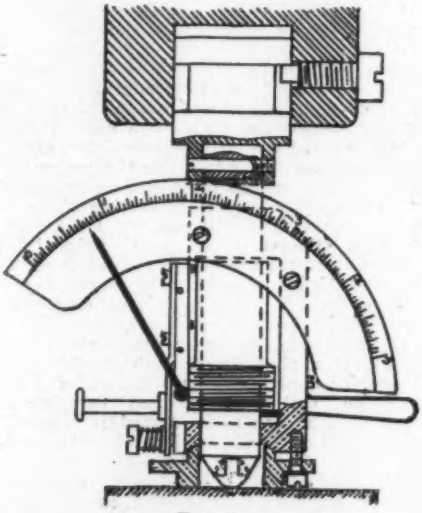


FIG. 5.

down on the chuck till the ring rests on the test piece. By pulling out the disengaging handle to the left, the pointer swings loose, and can be brought near to the zero mark before again engaging the screw. If the pointer still misses the zero mark, the milled head of the screw can be rotated slightly to make the coincidence exact. The desired load is next applied, and the ball, entering the metal under pressure, carries the pointer over the scale to a point indicating the depth of penetration. Elastic deformation must be allowed for by releasing the load to all but about twenty pounds, and then reading the correct depth. The construction is shown in Fig. 5.

A more recent form of the same type of depth indicator made by the firm is shown in Fig. 6, which illustrates the application of the same principle in the determination of hardness by means of the ninety-degree angle Ludwik cone. The knurled ring surrounding the cone rests with it at the same level on the smooth surface of the test specimen. When the cone, under pressure, enters the metal the knurled ring remains on the surface and pushes back the outer frame of the instrument and thus rotates the pointer over the scale, each division of which represents a depth of penetration of one-hundredth of a millimetre.

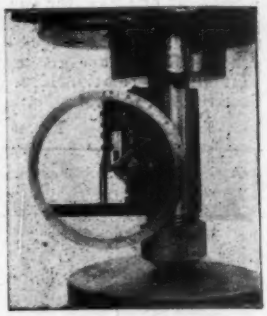


FIG. 6.

Guillery Machines.—A very useful form of portable hardness testing machine, the results from which can be arrived at without any measurement or calculation, is that designed by Mons. R. Guillery and made by Messrs. Malicet & Blin, of Aubervilliers. The simplicity of construction is

TABLE III.

Steel.	T.S. from Brinell No.	T.S. from Scleroscope.	Brinell No. from Scleroscope.
Carbon ..	0.325B—12.5	1.96S—12.5	5.6S+0.14
Nickel	0.318B—14.3	1.56S— 2.7	5.0S+0.48
Chrome-vanadium ..	0.318B—12.9	1.87S— 9.4	5.5S+0.27
Low-chrome-nickel	0.304B— 9.8	1.65S— 0.45	5.4S+0.33
High-chrome-nickel ..	0.318B—14.7	1.65S— 1.34	4.8S+0.58
Average ..	0.312B—11.6	1.8S — 6.7	5.5S+0.28

readily seen from the sectional view of the machine given in Fig. 7. The iron frame A contains in its lower part a powerful spring R which is made up of a number of discs forming a Belville spring. This is accurately standardised to give a pressure of 3,000 kg. to a plate Q carried on the central rod B passing through the spring, and this rod rests on the knife edge C. The forward movement of the hand lever G causes the cam F to raise the bent lever D about the fulcrum E and apply the load. The milled head I serves to rotate the screw V by friction, but this slips round immediately the hardened steel ball H, clipped securely to the screw, comes into intimate contact with the test piece placed on the supporting plate Q. The semi-circular scale M is attached to the upper part of the frame, and the pointer L is carried by slight friction on the plate J, which rotates with the screw V. In working the machine, the hand lever is first put back into the rear position, and the test piece is lightly gripped between the ball and the supporting plate by advancing the screw by means of the milled head until slipping takes place and the screw ceases to move. Then the pointer is brought over the zero mark

of the scale, the hand lever is brought forward to the front position, where it remains without being held for the required time, and it is then put back into its first position. In this way the ball comes out of the impression it has made and the screw is again free to advance and engage the surface of the metal in the indentation. The driving head I is therefore rotated until the screw goes no further and slipping occurs. This operation carries the pointer over the graduated scale to the same angle that the screw has turned, and for soft metals this operation of applying the pressure and advancing the screw is repeated till the screw will advance no further. This then measures the depth

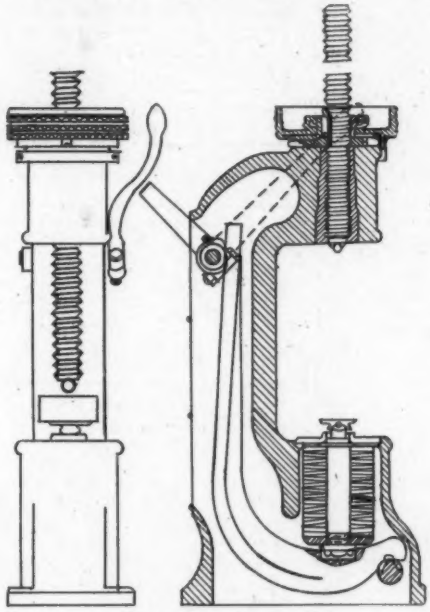


Fig. 7.

of the imprint, but the graduations on the scale are so arranged that it is not the actual depth which it indicated, but the corresponding Brinell hardness number. The sole precaution needed is to ensure that intimate metallic contact exists between the ball and the test piece, since any scale will spoil the correctness of the reading, which is ordinarily quite sufficiently accurate for commercial purposes. The hardness value can always be checked by measuring the diameter of the imprint in the usual way. A large size of this type of hardness tester has recently been brought out by Mons. Guillery, but as it works in the horizontal direction it readily enables the largest shells to be tested for hardness in any side position across a diameter. A sectional view of this machine is given in Fig. 8.

Impact Testing Machines.—The swinging pendulum type of impact testing machine, approved by the International Association for Testing Materials, is well known, but the Amsler vertical drop-weight machine mentioned by M. Charpy is less well known, and has recently been superseded by a new form of swinging hammer. This is shown in side view in Fig. 9, and consists of a heavy cast-iron base to which are bolted two upright channels supporting the pendulum and the elevating winch which can raise the pendulum either to left or right, depending upon how the detachable hook is attached. On falling from the left side the weight breaks the test piece transversely, and when falling from the right, tensile impact tests are made. A friction clutch holds the swinging arm in any desired position as the windless raises the bob weight, and the operating handle cannot be moved by the weight itself, but only by the operator. On pulling the release cord, the hook is detached and the tup falls freely, and after breaking the bar it swings up on the other side of the machine. Instead of swinging back, however, it is held in its position of maximum height by a third cord passing round a drum and acting as a brake. The circular weight at the end of this cord exerts a sufficient pull to prevent the pendulum from falling back from any position until it is released. To measure the energy absorbed by a blow of the pendulum the difference is noted between the readings of two scales provided on the vertical supports. The elevation of the weight moves a pointer over the first scale to show the energy stored before the blow, and the swing of the pendulum carries another pointer over a second scale to indicate the residual amount of energy after the blow. The change-over from transverse impact to tensile impact test is readily accomplished by unhooking the elevating cord from one side of the tup and fixing it to the other side, then the windless is wound up by turning the handle in the opposite direction from before.

One of the most convenient types of impact testers for works practice, which entails the minimum of effort and calculation, is the rotary dynamometer tup or rotating flywheel made

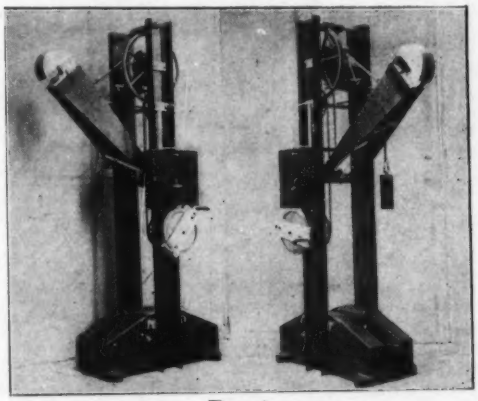


Fig. 9

by Malicet & Blin to the design of Mons. Guillery. The latest form of this machine, as shown in section in Fig 10, consists of a flywheel of such shape and size that when rotating at 302 r.p.m. the velocity of the striking knife is the same as that of a body falling freely from a height of four metres (say 29 ft.) per sec. The moment of inertia of the wheel is such that when running at this speed, the energy stored in it is 60 m.-kg. for the one size, and 275 m.-kg. for the heavier type of wheel, approximately 440 and 2,000 ft.-lbs. respectively. The lighter machine may be compared to a falling tup or "monkey" of 15 kg. weight falling from various heights up to four metres,

and these are registered by one of the speedometer scales. It is usual to work up to the highest reading and capacity of the machine, and for this

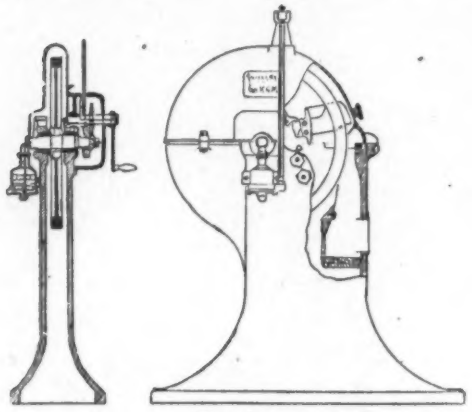


Fig. 10.

reason the scale for measuring the energy absorbed in the blow has its zero at the top of the tube.

moves up or down a float inside the centrifugal pump shown in section in Fig 11, and the vanes of this (rotated by bevel wheel from the axis of the flywheel) serve to raise a coloured liquid in the speedometer tube. A view of the machine taken with the cast-iron top cover removed from

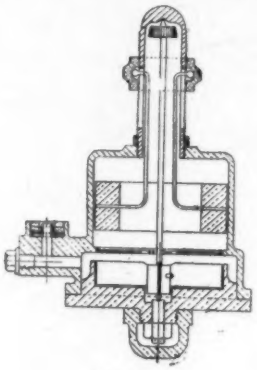


Fig. 11.

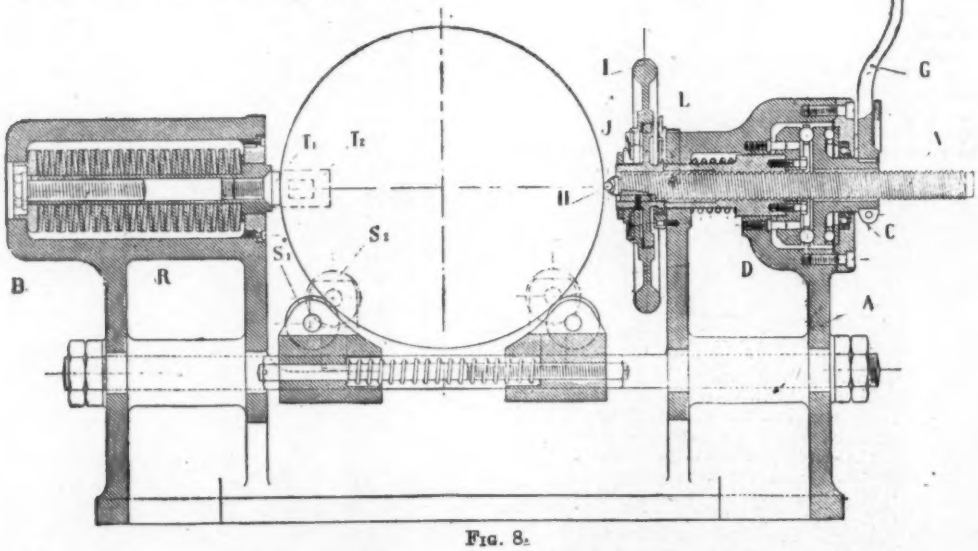


Fig. 8.

The flywheel of the machine is made to rotate by a handle connected with an adjacent lever which, according to its position, either puts the handle into gear for speeding up, or disengages to allow the wheel to run free. A third position applies a brake to stop the rotation of the wheel when the tests are completed. The connection between handle and wheel can be made readily when the wheel is in motion. An ingenious device throws the handle out of gear if it is attempted to turn the wheel in the wrong direction. The equivalent height of drop and the energy absorbed by the impact are read on the tachometer tube, the scale of which gives the highest reading when the wheel is at rest and adjusted to coincide with the 60 m.-kg. mark by means of a milled screw. This the lower casing and pedestal, shows in Fig. 12 the simple mechanism whereby the breaking knife is attached to the flywheel, so that when in the closed, or "in" position, the knife is completely enclosed within the rim of the flywheel.

Table IV. gives the results of several samples of mild steel which had proved brittle in working and which gave low impact values. A replace material, although similar in other physical properties, behaved well in service, and, on testing in the impact machine, showed much better results. The effect of heat treatment on some medium carbon steel as regards impact values is also shown in an interesting fashion.

Repeated-Impact Testing Machines.—One of the simplest forms of repeated-impact testing machine

recently introduced, to avoid the chattering sometimes met with, is the Eden-Foster machine, made in this country. A cam operates a lifting chain to engage a small vertical drop hammer, which is only released when the lifting mechanism is lowered to be clear of the fall. Two different weights of tup are used, and the whole apparatus is small and compact, although capable of taking the standard notched bar for this test. The bar is rotated in a simple friction clutch method whilst securely held in two plummer blocks.

TABLE IV.—*Physical Tests of Various Steels, showing Tensile and Hardness Tests Co-related with the Resistance to Shock represented in Foot-lbs. per sq. in.*

Steel.	Tested.	E.L.	T.S.	E. on 2 in.	R.A.	Brinell hardness.	Impact values
		Tons per sq. in.		Per cent.			Ft.-lbs.
Mild C.15	Long. ..	14.4	23.6	41.6	67.3	100	373
	Trans. ..	12.6	23.8	19.5	50.5	105	233
M C.18	Long. ..	15.0	29.0	33.2	51.8	115	580
do. ..	Trans. ..	14.4	28.0	26.3	35.0	110	700
do.	Long ..	18.2	26.3	51.0	53.0	110	1260
Mild C.2	Normal	12.4	21.8	10.0	9.0	105	380
do. ..	Forged ..	22.8	33.6	16.8	20.6	150	445
do. ..	Toughened	25.2	34.4	27.9	40.9	145	725
Med. C.34	Normal ..	20.2	33.5	28.0	48.0	122	467
do.	Oil quenched	40.0	52.2	15.0	54.0	230	890
do.	Double oil quenched	28.5	43.7	26.0	62.0	180	1260

A different principle is used in the quadruple hammer machine for repeated shock testing, as made by Messrs. Amsler Brothers. The bar to be tested is supported at the two ends, and a pair of hammers deal it blows alternately from right and

FIG. 12.

left until it breaks. The fracture is thus produced by fatigue. At the moment of fracture of the bar, the mechanism actuating the hammers is thrown out of gear and the blows cease. A counter indicates the number of blows received by the bar before fracture. The machine consists of four pairs of hammers working simultaneously upon four bars. The hammers receive their motion from a single shaft driven by a small motor. The pairs of hammers are quite independent of each other, and when one pair stops owing to the fracture of the bar, the other pairs continue their movement, so that the different bars are tested quite independently. The bars are cylindrical in shape, and 12 mm. in diameter, from 18 to 19 cm. long, as their supports are 17 cm. apart. These supports can turn on a vertical axis, which permits the bars to be bent freely by each blow, so that they do not behave like tightly-gripped bars. The blow of the hammers is delivered at two diametrically opposite points. The weight of each hammer is 5 kg., and they fall freely through a vertical height of 5 cm., so that each blow expends a quarter m.-kg. of energy on the bar. The counters record the number of rotations of the shaft, and thus the pairs of blows struck. The usual speed of rotation is about 90 r.p.m.

(The discussion on this Paper will be published in our next issue.)

Small Tools Order.

The Ministry of Munitions has issued an Order which notifies that the undertaking to be signed by, or on behalf of, dealers in engineers' and machinists' imported small tools is now cancelled, and the following regulations with regard to priority classification in respect of all small tools are imposed:—

No firm or person is permitted to issue a Class "A" Certificate with an order for small tools unless (*a*) such small tools form a component part of a direct Government contract, or (*b*) specially authorised in writing to do so by the Priority Department of the Ministry of Munitions; any applications for such higher priority must be made through the Director of Small Tools, Charing Cross Buildings, Embankment, W.C.2. Any Class "A" Certificate issued must bear the Contract Number in the case of (*a*) and the Priority Permit Number and Classification in the case of (*b*).

Firms holding a P.5 maintenance permit are authorised to quote their maintenance permit number and Priority Classification on orders for small tools up to the value allowed under the terms of their maintenance permit. All other firms and persons placing orders for small tools required for the unkeep of existing industrial plant should issue a Class "B" Certificate with their order.

The forms of Priority Classification Certificates referred to (sometimes known as Munitions Certificates) can be obtained from all the principal post offices.

Treadle Lathes.

A further Order, dated April 15, has been issued by the Ministry of Munitions directing that the war material to which Regulation 30A of the Defence of the Realm Regulations applies shall include Treadle Lathes of 3-in. centres or over suitable for use in cutting or working metal or for cutting, working or operating on wood.

All applications for a permit to purchase or enter into negotiations for the purchase of the war material referred to in the Order should be made to the Executive Officers of the Area Clearing House Boards whose addresses may be obtained upon application to the Director, Central Clearing House, Ministry of Munitions, Charing Cross Buildings, W.C.2. All applications for a permit to sell or enter into negotiations for sale of the war material referred to in the Order should be made to the Controller of Machine Tools, Ministry of Munitions, Charing Cross Buildings, W.C.2.

British Foundrymen's Association.

The Annual Conference of the above will be held at Sheffield on Friday and Saturday, June 21 and 22 respectively. Full particulars of the programme will be issued shortly. The Annual Meeting will be held on Friday, June 21.

BIRMINGHAM BRANCH.

The twelfth Annual Meeting of the Birmingham Branch of the Association was held on Saturday, March 23, the Branch-President, Mr. J. Shaw, presiding. On the proposition of Mr. Reason, Mr. J. J. Howell was elected President for the year, the proposer remarking that Mr. Howell was a gentleman of wide experience and in charge of one of the largest foundries in the Midlands. Mr. A. Harley was elected senior Vice-President, Mr. Wright (Wolverhampton) junior Vice-President, Mr. F. E. Shearman as Secretary, and Mr. Winterton as auditor.

A hearty vote of thanks was accorded Mr. Grindlay for his valuable services as Secretary, that gentleman explaining that owing to the long hours he was obliged to work he was no longer able to discharge the secretarial duties. The Council were elected as follows:—Captain P. S. Bayliss, E. H. Broughall, R. Buchanan, J. Bullock, D. Dalrymple, C. Grindlay, C. Heggie, F. Holberry, F. H. Hurren, C. B. Pugh, H. L. Reason, C. B. Roe, J. Shaw, and T. Vickers. In regard to the latter election, the Chairman remarked that Mr. Vickers, the Secretary of the Metallurgical Society, had been eminently successful in resuscitating that Society.

An invitation was conveyed from the Staffordshire Iron and Steel Institute to attend a meeting of that body on April 13, when a Paper was to be given by Mr. Primrose, of Ipswich, on "Continental Testing Machines." It was explained that Mr. Primrose had had a great deal of experienced on the Continent in connection with such matters. This Paper is reproduced on another page.

Following the formal business three Papers were read dealing with the melting of non-ferrous alloys and discussing the following points:—"Efficiency, best methods of working, and quality of metal produced." Mr. H. L. Reason (Birmingham) dealt with coke-fired furnaces, Mr. F. H. Hurren (Coventry) with gas-fired furnaces, and Mr. Andrew Harley (Coventry) with oil-fired furnaces. These Papers will be dealt with in our next issue.

LANCASHIRE BRANCH.

The ordinary monthly meeting of the Lancashire Branch was held at the School of Technology, Manchester, on Saturday, March 2. The Chairman (Mr. Key), in opening the proceedings, announced that in order to avoid any trouble with the military authorities, neither the Paper which was about to be read, nor any discussion which might follow, would be published. Mr. J. Masters, of Stalybridge, then read a Paper on "One method of making a new type of bomb: Aerial 80-pounders," in the course of which he dealt with the questions: (1) Method of making patterns and core boxes; (2) moulding boxes, sockets and chills; (3) template for setting cores; and (4) making of the cores, and the sand to use.

NEWCASTLE BRANCH.

A meeting of the Newcastle and District Branch of the British Foundrymen's Association was held in the Neville Hall, Newcastle, on Saturday, March 23, 1918, under the presidency of Mr. W. Mathews.

The paper down for discussion was "Suggestions for Research upon Cast Iron Test Bars," by Mr. H. J. Young, of Wallsend, but unfortunately the author, owing to indisposition, was unable to be present. On the suggestion of the President, the meeting was thrown open for discussion, and he himself inaugurated a debate on "Standard Test Bars," a subject which had been left over from the last open meeting of the Association.

THE PRESIDENT said that it had been suggested lately that instead of the Admiralty test bar as they knew it to-day there ought to be a certain number of "arbitration bars," 3 ft. long, by 2 in. by 1 in., cast separate and accepted as representing any particular day's melt, which should be tested for deflection and cross break. Whether that would give them a better bar was a matter for discussion, but in his opinion the present Admiralty demands for test bars did not seem to have any logic or sound reason at all. To-day they had large gear cases for turbine work, and the covers for those gears cases covered only the wheels or gear, and there was no load upon them, and similar bars were demanded in each instance. That did not seem to be reasonable at all. There was no relationship between the test bars and the casting they represented.

MR. PAULIN said the class of work he had been accustomed to was removed from the sphere they were discussing, but during the time that had elapsed since the war started that sort of thing had been forced upon one's attention. It had been impressed upon him that there was a good deal of nonsense talked about test bars. When they had, in normal times, arranged the moulding box to hold the minimum amount of sand and cast it with the minimum amount of labour, they did not in their standard manufactured articles consider any arrangements for planning the test bars. They were at the beginning of war fully equipped with moulding boxes of this description, and then they suddenly had thrust upon them the class of work for which test bars were demanded. Speaking to a gentleman recently on the subject, he said, "If you see the melted cast iron poured from the same ladle into a separate mould and so casting the test bar that there is a fair chance of life, would you be satisfied?" The reply he received was that he would require about 25 per cent. extra load. But he had no foundation for that sort of thing; it was pure guess. Because it was cast separately it had the opportunity of giving the best results that cast iron would under those conditions, and something more would be claimed for having promoted those conditions, which was an admission that test bars had not anything to do with the job. He dared say that that idea was open to this objection, which ought not to be an objection, that there might be more opportunities for fraud; that there was no visible connection between the article and the test bar. The first intention was to make a good job, and then, if the Fates permitted it, a good test bar. There was a good deal to be said for the separate casting of the test bar. One positive virtue was that if a man knew he had to pro-

vide test bars then he was careful with his mixtures.

Mr. Vardy could not understand why people wanted test bars. The Admiralty tests were relics of one hundred years ago. Why should they bother with such things? What they wanted was a good, sound casting. As for test bars, they could make them of anything they liked; the casting might be entirely different and it was a waste of time making them.

Another speaker said that the making of a test bar was more than merely casting it. It was all a question of when they cast it, and if they wanted a good, strong casting then they should cast it hot. One of the best ways to make a test bar was to make it separate inside a core, and then add a wood core print on the mould and drop the core on to that. The core print just referred to should be located on the outside of the mould.

Mr. Patterson said he knew of bars cast separately and also on the casting, and when the foundry was running on certain lines of work and the bar was put in a vertical position on the casting, they could get relatively good results from the bars on the casting. Casting the bar always in the same position on the casting gave some indication of the casting itself. If they put it on a different part of the casting each time they would get different results each time. But if it were done systematically they could get systematic results each time.

Mr. Gallon gave the details of a test bar he once made for an engineer, and sketched illustrations on the blackboard to show that the thickest part of the casting was not always the strongest.

Another member agreed with this, and said the explanation was that the thinner the casting the closer the grain. He had seen that proved in a number of cases.

The President asked whether it was better that the test bar should be in near proximity to the running gate, thus ensuring a constant flow of metal through the test bar as long as the mould was being filled; or whether it should be in a remote part of the casting so that there was no movement of metal after that part was filled. He had heard both conditions advanced as being the better.

A speaker said it should be run through the whole time the casting was filling, and the hotter the better.

Mr. Frier said the way was to run it in from one end instead of two. If they annealed cast iron they sacrificed strength for softness. The smaller the grain the better the result.

Mr. Paulin said the discussion indicated that the better way was to take the test bar from the bottom of the casting, to have it as hot as possible, and as far away from the casting, and to run it from one end. Those things had been pretty well established.

Several other trade questions were afterwards discussed.

LONDON BRANCH.

The last meeting of the Session of this Branch was held on April 12, Mr. T. W. Aitken (Branch-President) in the chair. A Paper on "Cupola Blowing and Efficient Combustion" was read by Captain Alexander Hayes, R.A.F., and a good discussion followed. This Paper will be published in our next issue.

SCOTTISH BRANCH.

The annual meeting of the Scottish Branch of the British Foundrymen's Association was held at Glasgow, on March 23. Mr. Matthew Riddell, the Branch-President, occupied the chair. The following office bearers were elected:—*President.*—Mr. R. R. McGowan, Glasgow. *Vice-Presidents.*—Mr. Wm. Bell, Glasgow; Mr. A. Fraser, Hurlford. *Treasurer.*—Mr. John Logan, Ardeer Foundry, Stevenson. *Secretary.*—Mr. John Macfarlane, 3, Sharrocks Street, Ibrox, Glasgow.

Members of Branch Committee.—Messrs. G. McKay, Paisley; R. Robertson, Falkirk; R. Clark, Falkirk; Dr. Desch, Glasgow University; H. Williamson, Dalmuir; A. Lawrie, Hurlford; J. Thompson; J. Cameron, Kirkintilloch; and J. W. Twiggins, Renfrew.

The number on the roll at the end of the financial year was 186, and the average attendance at the meetings was 73. The balance-sheet showed that the total expenditure for the year was £22 6s. 8d.

The following motion was passed:—"The members of the Scottish Branch of the British Foundrymen's Association desire once more to place on record their indebtedness to the Governors of the Royal Technical College for the excellent facilities granted to the Branch in the use of the College Buildings."

Mr. R. Buchanan, F.R.S.A., then read a Paper on "A National Information Bureau for Foundrymen," in which he stated that the principal object of his visit to the Scottish Branch was to try and create an interest in and enlist the support of the Scottish members in this scheme, which he proposed to bring before the Annual Conference of the British Foundrymen's Association at their meeting in June. The object of such an institution would be, for the first few years at least, to mobilise all the available information pertaining to foundry work, and place it at the disposal of the community. Such an action would be necessary because of the fact that international competition in the near future would be more intense than ever. The financial burden on every country will make it a necessity that waste in production must be reduced to a minimum, and to bring about this condition, the concentration of every effort and scientific knowledge will be brought to bear on the advancement of trade.

The application of science to trade must assume a more prominent position than hitherto. If such an institution as that suggested had been established prior to the war, what an advantage it would have been to the foundry trade and the country generally! Hitherto foundries had been far too individualistic in their actions, and their apathy towards science had been very apparent. But the methods which ruled in pre-war days no longer held good. In war it was the best equipped army which won, and in a like manner with trade, the country which had its trade organised on thoroughly scientific lines must be most successful.

The lecturer described in full the scope and functions of the scheme and its financial aspects. He appealed to the members of the Scottish Branch for their support in this endeavour to establish a National Information Bureau for Foundrymen.

An interesting discussion took place on the different aspects of the scheme, and a vote of thanks was accorded to Mr. Buchanan for his lecture. The meeting thereafter passed a resolution pledging itself to support the scheme.

LANCASHIRE BRANCH.

A meeting of the members of the Lancashire Branch was held on April 6, Mr. Key presiding.

Types of Cupolas.

A Paper, illustrated by lantern slides, was read by MR. S. ROE, of Oldham, on "Various Types of Cupolas." He said the ideal apparatus for the melting of metals was that which melted them out of contact with the fuel or with the gases developed by the combustion of that fuel. Such an apparatus was the electric furnace. Next in order of perfection came the reverberatory furnace, which melted its metal out of contact with the fuel, but not out of contact with the resultant gases. Along with this type might be mentioned the crucible furnace employed in brass and, in special cases, in malleable iron and steel melting. Next came the cupola.

He did not intend to deal with the early history of the foundry furnace, except to mention the first type, but he would speak of later steps taken in arriving at the present type of furnace. In his opinion the cupola in use to-day was as good as it could be made, considering that the metal melted and the fuel were in contact during the melting process. Until such a furnace as the electric furnace was adopted they would have to put up with the difficulties which everyone in charge of such a type of furnace knew so well.

The old foundry furnace was rectangular in shape, in sides being 2 to its end 1½. The height varied from three to four times the length of the sides. It was formed of cast-iron plates having flanges for bolting together, and the top was an arch of brickwork. A lining of brickwork was built inside, and the furnace stood on a mass of brickwork 3 or 4 ft. high. It had four or five tuyeres on each side, placed about 9 in. or 10 in. above each other, and the air was carried from the fan pipes to a copper elbow through leather hosen. These leather hosen were used to allow the air pipes to move flexibly when raising the copper elbow from one tuyere to the tuyere above it. The furnace was lighted off in the usual way through a feed hole at the back, the front made up, and all the tuyere holes rammed up with sand except the two bottom ones. The fan was then started, and when the metal accumulated to the height of the first tuyere the fan was stopped, the copper elbows lifted to the two tuyeres next higher, the lower was rammed with sand and blowing recommenced. When sufficient metal was accumulated, or when the furnaceman's courage failed, the fan was stopped and the furnace emptied. This shape of furnace was probably adopted because the usual shape of the thenadays firebrick lent itself more readily to a rectangle than to a circle.

Another early type of furnace was still in use in some of the remoter corners of the earth, and was known as the Foundrie à Calebasse. This furnace was of the cheapest and simplest construction and was very capable for the purposes it was used for. It consisted of a ladle, cast-iron or wrought-iron, such as were used in English foundries, with a bow or shank for lifting purposes; a cylinder of boiler plate which with the ladle formed the furnace stack, a firebrick wall provided with a sheet-iron hood and chimney to conduct away sparks and smoke, a small smith's fan with flexible tube attached to a metal or earthenware tuyere. Such was the apparatus which made up the Calebasse, and it was used as follows:—

The ladle was lined in the ordinary fashion, except that the lining was brought over the upper edge of the ladle. A fire was placed in it to dry the lining. The metal cylinder was lined in the same way. A roll of clay was placed around the edge of the ladle and the cylinder bedded down into the clay. This also was dried by the fire in the ladle. Through this roll of clay was left a hole to accommodate the tuyere. The ladle and cylinder were placed against the firebrick wall in such a position that the hole through the clay roll was opposite a hole provided in the wall. It was now well rammed round with sand. The tuyere was passed through the hole provided, wedged into position, and luted round with clay. More fuel was put into the Calebasse, and a gentle blast was put on. When the fire had sufficiently burned up the charge of fuel, coke or coal and metal was put on, and the blast increased. A fairly large driving wheel was required, as 800 to 1,000 revs. per minute were necessary to produce the requisite pressure of blast. When the metal was down the sand was removed from round the ladle and the cylinder removed by a bar passed through the eyelets provided, when the fire fell away and was raked off the surface of the metal in the ladle. The amount of metal that could be melted by this method depended upon the size of ladle used, and might vary from a few pounds to half a ton. The apparatus shown was capable of producing 5 cwts. of metal at one operation, and the time required for melting was one hour. In the apparatus described a fan was employed, but in localities where a fall of water was available an instrument known as the Trompe was used, such an one as was used in connection with the Catalan forge.

Mention of the Trompe called to notice another method of blowing as applied to the Woodward cupola. Woodward's cupola was worked by means of an induced current of air caused by a jet of steam blown into the upper portion of the cupola instead of by the usual means of fan or blower. This cupola was stated to have worked well and to have been more economical in coke consumption than the ordinary cupola. Its great virtue, however, was its extreme simplicity. The steam necessary to create the draught was only equivalent to the amount of steam required to drive an engine sufficiently strong to drive the fan of a present-day cupola. It was claimed that the consumption of coke was no more than 1¼ cwt. of coke per ton of iron melted. The steam pipe was arranged to blow through a side flue into the chimney. The jet was a simple nozzle, and the pressure of steam was any ordinary boiler pressure. The furnace was fed by a hopper such as used on blast furnaces which, when filled with either iron or coke, could be emptied by operating a lever. Two rows of tuyeres were provided, four in the bottom row and eight in the top. Each of these tuyeres could be closed by a valve at will. The furnace was charged in the usual way, and when in operation the draught was regulated by the man in charge, care being taken to close any of the tuyeres against which any semi-molten metal might lodge. This had the effect of directing the blast to this spot, increasing the temperature and melting the obstructing metal.

Another example of the same type, *i.e.*, where the draught was induced by a jet of steam, was the Herbertz cupola as described by Mr. Rhead. It was provided with several heights of tuyeres. The upper portion of the cupola was separated from the lower portion forming the well. This

space provided an inlet for air when extended round the cupola, and could be increased or decreased at will according to the necessity for more or less blast.

Heaton's cupola depended for its draught on neither jet of steam nor fan, but simply on the obedience to natural laws of a heated current of air. The cupola was provided with a tall chimney stack similar to that built alongside the boiler-house of every cotton mill. This method was extremely slow, as the cupola required carefully and slowly heating when being put into operation.

The simple chemistry of combustion within the cupola was that of the kitchen firegrate. Air was forced into the cupola, which came in contact with the heated coke. The oxygen of the air with the carbon of the coke formed carbonic anhydride (carbon dioxide, CO_2). This gas, which was non-inflammable, was brought into contact with other heated carbon, and took up another atom of carbon, becoming carbonic oxide (carbon monoxide), CO. This was inflammable gas, and when, on reaching the top of the charge, it came in contact with air it burned, becoming carbon dioxide. This represented a waste of heat, and attempts had been made to bring this conversion about before the CO reached the outer atmosphere. Such an attempt was made by the Greiner & Erps cupola. An ascending range of tuyeres was provided to introduce oxygen to the ascending CO, thereby causing its conversion into CO_2 and an increase in temperature at the various points of the cupola due to the chemical changes. Theoretically, this argument was sound, but experiment proved that no advantage was gained by the additional tuyeres. Other attempts had been made to conserve the hot gases, and so retain their heat. Such an one was shown in the cupola represented on a view submitted to the members. It was termed an expanding cupola, and was said to have given very good results. The diameter of this cupola at the tuyeres was 3 ft. and at the charging door 6 ft. Its peculiar design admitted of heavy charges, and was calculated to ensure the melting of the metal before reaching the parallel portion opposite the tuyeres. The following were the statistics relating to the working of this cupola :—

Initial charge of coke	8½ cwt.
First charge of iron	10 ,,
Second charge of coke	1½ ,,
Second charge of iron	20 ,,
Running consumption of coke per ton of iron	1½ ,,
Coke required to melt 5 tons of iron ...	15½ ,,
Rate of melting per hour	6 tons.
Pressure of blast	4 ozs.
Diameter of tuyeres	5½ ins

Another slide showed two early cupolas resembling in shape somewhat the expanding cupola. The first one was enclosed in cast-iron plates. The second one was of similar type, but the contraction above was less marked. The principal dimensions of the cupola were as follows :—

	Ft.	In.
Diameter at hearth	4	10
,, charging door	3	0
,, top of chimney	1	6
Height from base plate to the sill of charging door	8	4
Height from door sill to top of chimney	18	0

The principal dimensions of the second cupola were :—

	Ft.	In.
Diameter at hearth	3	3
,, charging door	3	0
,, top of chimney	2	6
Height from base plate to sill of charging door	7	0
Height from door sill to top of chimney ...	16	0

Ireland, one of the pioneers in cupola construction, introduced the air belt, and one of his earlier cupolas was shown. The air belt, instead of being outside the furnace as in the modern type, was shown as being between the brickwork and the casing. Two rows of tuyeres were provided, eight in the upper row, and the two main tuyeres. Ireland's cupolas were the first to show that sudden decrease in diameter near the tuyeres known as the bosh. The upper tuyeres were 2 in. diameter and placed 1 ft. 7 in. above the lower ones, measuring from centre to centre. The lower ones were 6 in. diameter. The principal dimensions were :—

	Ft.	In.
Diameter at sole or hearth	2	6
,, cyl. of bosh	1	7
,, above the bosh	3	0
Height from hearth to bottom of bosh ...	1	6
,, of cyl. of bosh	1	2
,, bosh	2	4
,, cyl. above bosh	6	4
,, chimney above sill of charging door	12	0
,, centre of tuyeres over sole ...	1	6

In Ireland's quaint phraseology the directions for the management of this cupola were :—"The cupola must be filled with coke about half-way into the boshing, and then put on about three handsful of limestone. Then put on the pig-metal across the centre of the furnace, with the ends of the pigs towards the tuyeres, piling up the sides with scrap, and cover the whole with coke. If the weight of metal be 20 cwt., put on 10 cwt. at a time, proportioned 7 cwt. of pig and 3 cwt. of scrap, and cover well with 4 riddles of coke. If the weight of iron be between 20 cwt. and 26 cwt., divide it into two equal charges, and put between each of the charges four riddles of coke. Put three handsful of limestone between every charge."

The superiority of this class of cupola over the old straight-sided type consisted in the shape of the interior, *i.e.*, the bosh, the height and the perfect management, if the instructions were followed.

The Mackenzie cupola, of American origin, was elliptical in plan and, not depending on tuyeres, the blast was discharged into a hollow space, which extended all round the furnace at the base. From that hollow space it entered the furnace through an annular opening. When blowing commenced it was necessary to commence with a very light blast, but as the iron came down the pressure was increased to 2½ lb. per sq. in. This furnace showed in its internal construction a tendency to adopt the bosh of Ireland's cupola. The dimensions of this furnace were :—In the bosh 7 ft. 6 in. by 3 ft. 6 in. and 8 ft. 6 in. by 4 ft. 6 in. at the largest point. Its height from the tuyeres to the charging door was 9 ft. 6 in. The tuyeres, or the annular space which acted as the tuyeres, was 1½ in. wide, and it extended all round the furnace at a height of 8 in. from the bottom. The provision was made for slag, and the average quantity of metal which could be drawn from this cupola before the air space became so clogged as to interfere with the blast was 30 tons.

Some of these Mackenzie cupolas were built rectangular in plan and to large dimensions, which was necessary where anthracite was used as fuel. The object of this shape of plan and method of introducing the blast and at great pressure seemed to aim at driving the blast to the centre of the cupola, and cause it to rise through the centre of the burden or charge. The tendency, as they had all noticed, was for the blast to creep up between

the charges and the brickwork. This, besides shortening the life of the furnace lining, meant a loss of heat, which would, if the blast were rising through the charges, be absorbed by the metal, thus effecting a saving of fuel.

Another type of furnace which aimed at this object was the Krigar cupola. This German cupola was described before the Institute of Mechanical Engineers some years ago, and was stated to be very efficient and to melt its iron very clean and fluid. The average quantity of coke consumed was 1¼ cwt. per ton of iron melted. Recent examples of this type had been considerably modified, being circular in section, and having a receiver provided for collecting the metal.

Another attempt at getting all the blast to the centre of the cupola was shown in West's centre blast cupola. This arrangement undoubtedly did get the blast to the centre, but any advantage gained thereby would be outweighed by greater disadvantages. The tuyere pipe would require very frequent renewal.

The Voisin cupola was much in vogue in France. It was built with a drop bottom and an air belt, and had a well-defined bosh. It was supplied with two rows of tuyeres, four in each set. The tuyeres in the lower row were arranged opposite and at right angles to the main. Those in the upper row were arranged diagonally to it. The inventor claimed for this arrangement of tuyeres that a second zone of fusion was created, thus overcoming to some extent the evil due to the formation of CO_2 without a further conversion to CO. This upper row of tuyeres was seen in the Herbertz cupola, and, as was proved by the experiments made by Greiner & Erps, their utility seemed to end with the second row, a decrease in the temperature of the upper part of the cupola being caused by an admission of too much air, when the combustion of the gases did not occur. The principal dimensions of the Voisin cupola were :—

	Ft.	In.
Diameter at heartb	2	0
Height of hearth	1	10
,, cyl. portion of bosh	2	4
,, slope...	1	2
Diameter of cupola above bosh	2	4
,, ,, at charging door ...	1	10

The height from hearth to sill of charging door was 11 ft. 6 in., which was somewhat large for this diameter of cupola, but the fullest advantage was taken of the absorption of heat, by the charge, of the ascending gases.

In charging this cupola, the bed was formed with 3 cwt. of coke. The charges were ½ ton of pig and scrap; subsequent charges of coke, 56 lb. Rate of melting rather under 4 tons per hour. Pressure of blast, 8.66 in. of water.

The Newton cupola, of American design, had two rows of tuyeres in an air belt. The tuyeres in the lower row were so large as to form an almost continuous circle. They were expanded towards the interior of the cupola, and in the centre of each were placed two plates in such a fashion as to divide a portion of the blast. This had the effect of increasing the pressure of the centre position, which, as a consequence, was driven to the centre of the cupola. The remainder entering on each side of the plate was diffused in a gentler fashion to the other parts of the melting zone.

Discussion.

In opening the discussion, the CHAIRMAN said the Whiting type had been adopted for two new cupolas he was concerned with, and he did not know whether it would do all that was claimed for it.

MR. HAIGH said the Woodward type, if it fulfilled what was said on its behalf, would be very acceptable at the present time. A consumption of 1¼ cwt. of coke per ton melted was the kind of thing wanted. It would be interesting to know why some old types, which were certainly good, had been abandoned.

THE CHAIRMAN asked whether Mr. Roe had worked out the melting capacity per sq. in. of area on each type. It was that, coupled with the coke consumption, which determined the value of the cupola. There ought to be a standard in first-class cupola practice.

MR. ROE said the Woodward was in operation in the 'eighties. The 1¼ cwt. was an exceptionally good figure, and he did not know whether it simply meant the coke between the charges of metal or whether the bed of coke was included. Perhaps if exact data were obtained a different complexion would be put on the thing. This cupola was referred to by Spretson, and had been mentioned once or twice before the Institute of Mechanical Engineers. He had not worked out the melting capacity per sq. in. of area, but it could be easily arrived at from the diameter of the furnace and a given consumption of coke.

MR. SHERBURN, jun., said one of the difficulties in melting iron under the present conditions was that it had to be an intermittent operation. If a continuous process of melting could be devised they would get much nearer to economical working. Worked out on the thermal side, the melting by cupolas was extremely wasteful, and if a simpler method, working on the lines of the blast furnace, could be devised it would be more economical. If it could be arranged to supply a standardised coke throughout the country, no doubt cupola design could be standardised also, but under the present conditions it was very difficult to get anything like uniformity.

No doubt every member had his opinion as to some modification which would produce the condition most suitable for local working. One could not lay down a hard-and-fast line either as to the shape of the internal structure or as to the disposition of the tuyeres. In the course of his address Mr. Roe had mentioned the electric furnace as one in which the metal did not come in contact with the fuel. That was not quite correct. Carbon was consumed in the process, and there was a slight contact with the fuel. One of the points on which information was wanted was whether it was really advisable to restrict the cupola down at the tuyeres or whether it was advisable to have a straight shaft. Some people thought the straight shaft was all right for a start, and then the furnace could be allowed to take its own way to a slight extent and make its own shape. In one instance he recalled the result was to slightly increase the size in the melting zone. Before anything like agreement as to shape or type could be obtained the material must be standardised, and he did not know whether they would get that.

MR. ROE replied that continuous melting was an ideal, but scarcely a possibility, under existing conditions. In the electric furnace some carbon was taken up by the metal melted, but the amount of carbon that the iron received from the electrodes was infinitesimal compared with the amount that would be received from the coke.

MR. MEADOWCROFT said in regard to cupolas they were backward in knowledge, and there was a

great field open for research. It ought to be within the province of a district like Manchester to do something towards the development of that field. The members had furnaces which operated in various ways, and if they could gather definite information as to the results obtained under certain conditions it would be very valuable when co-ordinated. A great deal depended on the material which was being melted. As far as his experience went, the Whiting cupola was not economical. It worked all right, but it did not melt 1 ton with 1¼ cwt. of coke. The Woodward was an interesting type, and might be brought into prominence again. It was unfortunate that the foundryman received little encouragement from other people when he tried to improve; he was left to struggle on in the old way. Often enough all the interest taken in his work was to grumble because he was using so much coke. He had hoped to get some information from Mr. Roe which would enable him to reduce the coke consumption, but he had not got it yet.

Mr. Chadwick remarked that a great deal depended on whether the coke was dry or not. With wet coke the consumption increased enormously.

Mr. Roe agreed with the last statement. In Mr. Meadowcroft's case the 1¼ cwt. would be a low consumption, because hematite iron required more melting than the ordinary brands of iron.

The Chairman asked whether any member had experience of a spout 12 ft. long, because he had a case in hand where it might be necessary. Where he served his time the big ladle was put into a pit 12 ft. away from the furnace.

Mr. Meadowcroft said in a certain case he made a spout about 4 ft. from the receiver, and let it off at right angles. The branch spout was 15 ft. long, and they had no trouble although casting machine work.

Powdered Fuel in Open-Hearth and Small Heating Furnaces.

The use of pulverised coal in metallurgical furnaces was the subject of a Paper presented to the Cleveland Engineering Society (U.S.A.) by Mr. H. G. Barnhurst, of the Fuller Engineering Company, who said that the danger of spontaneous combustion of pulverised coal had been greatly exaggerated. Nothing more than precautions usual with all fuels were necessary to guard against it. However, the presence of pyrites tended to incite spontaneous combustion. The power required in a coal pulverising plant was about 17 h.p.-hrs. per net ton (2,000 lbs.) of coal pulverised. This included drying, elevating and conveying. The repair costs should be somewhere between 2½d. and 3½d. per net ton of coal handled.

The drier fuel, continued the author, is practically a constant amount per ton of coal dried with a given moisture content. Where the coals carry from 5 to 10 per cent. of moisture as received, from 25 to 35 lbs. of coal are required to a ton of coal dried. An evaporation of from 5 to 7 lbs. of moisture from the coal being dried can be obtained per pound of coal burned on the grates of the drier. Coal should be dried so that its moisture will be less than 1 per cent. The modern pulveriser can handle coal having from 3 to 5 per cent. moisture. Generally speaking, coal in large quantities from 50 to 100 tons and upward can be pulverised and delivered to the furnaces at a cost of from 10d. to 2s. per ton, depending on the quantity handled. This does not include interest and depreciation, taxes, overhead expenses, etc. A good plant with a capacity of 100 tons of pulverised coal daily will cost from £60 to £80 per ton of coal pulverised. The cost of a plant for 250 tons daily capacity of pulverised coal will be from £50 to £60 per ton. To the cost of the pulverising plant must be added the cost of the conveying system to the furnaces, also the storage bins, burners, etc., as well as the air supply. More power is required to convey coal by air at such a velocity as will prevent its filling up in the blast pipes than is used where screw conveyors are installed. The necessity of closing up every leak makes an air system expensive to operate.

Tests made on furnaces of the Calumet Steel Company, burning pulverised coal and used in connection with an 8-in. mill, indicated that for scrap material running from small rails 2 ft. in length up to 2-in. billets 6 ft. long, and totalling 25,000 lbs. daily, the use of pulverised coal costing 11s. per net ton (2,000 lbs.) as compared with oil at 1½d. per gallon effected a saving in fuel of 49 per cent. or £2 7s. a day. In addition it was found that the average scale when oil was used amounted to 5 per cent., whereas when pulverised coal was used there was at least 2 per cent. reduction.

At the Atlantic Steel Company there is an installation of a 50-ton open-hearth steel furnace which has now been in operation since November, 1915. It has been averaging about 400 lbs. of coal per ton of steel tapped from a cold charge. Open-hearth furnaces previously fired by means of producer gas require some change in the conformation of the flues and the installation of removable slag pockets, and the rearrangement of the regenerating chambers, eliminating a certain amount of chequers and replacing them by means of baffle walls. The cross-sectional area of the flues of the furnace and the chequers must be proportioned properly, so that excessive velocity of the gases is not permitted.

The use of pulverised coal will reduce the quantity of fuel required from 30 to 40 per cent. as compared with the gas producer. Coals with ash as high as 17 per cent. have been used recently, but these are likely to choke up the chequers, particularly in an installation where the chequers have not been designed for pulverised coal-firing but for other fuels. At one plant the best test was obtained with coal having the lowest per cent. volatile matter, which ran down as low as 20 per cent. There is no necessity for making any change in the shape of the furnace proper, that is, the combustion chamber. A distance of not more than 16 ft. to 18 ft. from the point of entrance of the fuel to the edge of the bath should be allowed. The velocities should be low when pulverised coal is used because of the erosive effect when too large quantities of coal are fed into the chambers. Between 40 and 60 cub. ft. of regenerative volume per ton of steel is the proper proportion. Less regenerative brick is used because of the small quantity of air passed through the chequers. From 20 to 25 per cent of the air enters with the coal. The company's design directs the gases first downward, then to swing round and up, and then over and down through the chequers. As a result of these changes of direction there is deposited a large percentage of the ash carried in suspension. A removable slag pocket takes care of this.

Carbon Monoxide Poisoning in Steel Plants.

In a Technical Paper entitled "Carbon Monoxide Poisoning in the Steel Industry," issued by the U.S. Bureau of Mines, Mr. J. A. Watkins calls attention to the injurious effect of the continued presence of small quantities of carbon monoxide gas, which, although insufficient to cause acute symptoms of poisoning, will, nevertheless, by insidious action finally bring about the same result —that is, total or partial incapacitation of the worker. The following is a brief abstract of the Paper.

In discussing the cumulative effects on men of monoxide inhaled in small quantities (that is, quantities insufficient to cause complete collapse by "gassing") daily and over extended periods, there should be borne in mind the following factors:— (1) That the factor of individual resistance enters largely into the results; (2) that man has some power of resistance to small quantities of monoxide, as his bodily mechanism adjusts itself for a short time to such abnormal conditions by means of that reserve power with which all vital tissues are endowed. This does not mean that man is not affected or immune to monoxide, but merely that because of physiological adjustment he does not become sufficiently ill or have symptoms serious enough to bring about his incapacitation. The results of both forms of poisoning will be the same, the only difference between the two being in the time required.

In a steel plant monoxide may be found about the blast furnaces and in other localities. The smelting of iron ore with coke and limestone develops enormous quantities of gas—about 150,000 cub. ft. per ton of fuel consumed. Blast-furnace gas contains 22 to 27 per cent. monoxide. The gas, after being washed, is used to heat the blast or is burned under boilers or used for gas engines. Owing to improved methods of construction and working, and the rare exposure of men at the furnace top, the hazard of gas poisoning at the top, which was formerly great, has been reduced. If a man should become "gassed" while working on top, the gassing would be acute in character. Proportions sufficient to cause asphyxiation may occur also all along the route of the gas, and at times, but rarely, through the furnace wall. There is also always some leakage, although in varying amounts, from the tapping hole and slag notch while they are open during casting. The gas as it comes from the furnace can be easily detected by the eye, owing to the dusts suspended in it, and by its odour. After passing through the washers it is usually invisible and practically odourless, and consequently gives no warning of its presence.

The blast-furnace gas, after being washed, is often conducted through a main beneath the floor of the engine-house to gas engines, and leakage often occurs, sometimes in sufficient quantity to cause collapse of the workers from acute poisoning. At one plant cases of monoxide poisoning occurred regularly over an extended period of time in spite of all precautions. Gas may also escape from the exhaust. The exhaust gas has a carbon monoxide content varying from 22 to 27 per cent. if unexploded and from 0.35 to 1 per cent. if exploded.

In steel plants producer gas is made in large quantities and burned principally for heating metal. In addition to occasional leaks in the producer walls or other parts a conspicuous source of the gas is at the hoppers. The gas, which has a monoxide content of about 20 to 25 per cent., escapes rapidly in large quantities, when the hopper lid is left partly open. Symptoms of insidious monoxide poisoning are common among those employed in this department.

In the foundry, open-hearth furnaces, and other places, cupola furnaces have been operated in many instances in such a manner as to allow considerable opportunity for escape of gas containing monoxide. Cupola furnaces are usually open at the top, and in some instances the place of duty of the worker is above the furnace, as in the case of the cranemen and chargers. Acute poisoning among these became so severe and frequent at one plant that difficulty was experienced in obtaining men to fill these positions.

At certain steel works dolomite is burned with coke in furnaces as part of its preparation for use as a refractory material. One of the products of this combustion is monoxide. The furnace being open at the top, the gas freely escapes into the air, and chargers and cranemen are particularly apt to be exposed, as they work at times around the top.

It is the custom in many American steel plants to construct small inclosures, 3 to 4 ft. square, in which the men may rest when off duty. They are generally in use only during cold weather, and are heated with an open coke fire. A few fatal cases of monoxide poisoning have been reported, and slight gassing occurs with some frequency.

While making a sanitary survey of the steel industry in the Pitsburgh district, the writer's attention was repeatedly called to the subject of monoxide poisoning. A number of air samples for chemical analysis and determination of monoxide were therefore taken at different times, over a period of several weeks and under varying conditions of weather and plant operation, in places where the men, in most instances, were actually at work. Evacuated and hermetically-sealed containers were used in the form of glass cylinders of the desired capacity, sealed at one end. The other end was drawn out into a capillary tube 5 cm. long, having a bore of about 1 mm. This was attached to a pump, with a manometer, the cylinder exhausted, and the capillary tube sealed in a flame. At the place of sampling the capillary tube was broken off at a file mark, permitting the air to rush into the cylinder. The tube was then hermetically sealed with beeswax and turpentine, and forwarded to the laboratory for analysis. Briefly, the method used in the analysis of the samples was as follows:—The carbon dioxide is absorbed in caustic potash; the O_2 is absorbed in alkaline pyrogallate solution; the H_2 and CO are burned in a slow combustion chamber by a hot platinum wire. The N_2 is determined by difference. Two check analyses were made of all samples, and in some instances additional qualitative tests. The burette on the gas analysis apparatus with which the samples were examined was graduated in 0.01 c.c. and could be accurately read to within 0.002 to 0.004 c.c. All figures are within a range that makes the maximum error not more than 0.02 per cent. The content, expressed in percentages, of monoxide in the air to which workers are exposed is given in a tabular form:—

Where sample was taken	Occupation of men.	Carbon monoxide content.
Blast furnace.		Per cent.
Close to runway ..	Front gang while casting	0.02 to 0.24
At scrubbers.. ..	Repair men ..	0.94
At dust catcher ..	Labourers	0.03
Gas Engines.		
In blower room ..	Blower room men ..	0.01 to 0.10
Engine-room cellar ..	None continuously ..	0.02 to 0.04
Near gas engine ..	Engine-room men ..	0.03 to 3.4
Cupolas.		
Above cupola ..	Cranemen and chargers	0.02 to 0.10
Gas Producers.		
Platform	Firemen	0.03 to 0.58
Coal bins above ..	Chargers	0.07 to 0.10
Dolomite shed.		
Various positions ..	Cranemen, etc. ..	0.00 to 0.42
Miscellaneous.		
Rest shanty	Resting	0.05 to 0.23

Many data available from experimental work on monoxide poisoning and from observations made in serious or fatal cases of asphyxiation with this gas, justify the statement that exposure to 0.2 per cent. of monoxide for thirty minutes will be sufficient temporarily to incapacitate the person so exposed. An increase in the amount of monoxide or the length of exposure would be rather dangerous. Serious symptoms may result from continued exposure to so small a quantity of monoxide as 0.01 per cent., especially if the exposed person does much physical work. From an industrial hygienist's standpoint the air of any place where men work which contains 0.01 per cent. of monoxide is dangerous.

In conclusion the author recommends that a survey should be made in every steel plant with the view of finding out whether monoxide is escaping into the air breathed by workmen, and some system of regular periodical inspection instituted. It being a comparatively simple matter to obtain samples of the air by the method described, they could be taken by unskilled persons, and the qualitative or, if need be, the quantitative determination of the monoxide content of these samples could be made with little additional expense or labour in the chemical laboratory. In all places where there is likelihood of the air being polluted by monoxide, provisions should be made for ample ventilation, both by natural and artificial means.

Acid-Resisting Iron.

In a Paper read before the London Section of the Society of Chemical Industry recently, MR. SYDNEY J. TUNGAY discussed the developments in the manufacture of acid-resisting iron, especially for chemical plant. It had long since been proved in the laboratory, he said, that a pure form of iron could be rendered resistant to either sulphuric or nitric acid by the addition of a suitable proportion of silicon, chromium or other elements, but the development of such metals upon an industrial and commercial basis was not approached until some twenty years ago. In more recent years the development of the electric furnace had proved a valuable aid in the satisfactory commercial production of such alloys as ferro-silicon and ferro-chromium. Tests made by Kowalke, in America, had shown that silicon present in a lesser quantity than 12 per cent. did not promote satisfactory resistance to corrosion, whilst when it reached 19 per cent. or more, the acid-resisting quality of the alloy again fell. In addition to the difficulties presented by the serious shrinkage of non-corrosive iron castings during cooling, which amounted to slightly over ¼ in. per foot in each direction as compared with a shrinkage of about 3-32 in. per foot in the case of ordinary cast iron, the presence of graphite in any considerable quantity caused disaster. The iron must also be low in carbon and phosphorus, otherwise during the process of cooling these compounds tended to separate out and form eutectics. These difficulties, however, had been largely overcome by suitable furnaces and by improved manipulation in mixing the metal, with the result that in present commercial practice it was found quite possible to produce a satisfactory acid-resisting iron, though its application to the manufacture of plant for the chemical industry had not until recently been completely successful. The following were the physical constants of acid-resisting iron as compared with cast iron :—

	Cast-iron.	Acid-resisting iron.
Density	7.3	6.8
Tensile strength (tons per sq. in.) ..	9–10	6–7
Melting point (deg. C.)	1150	1200
Hardness..	24	35
Heat conductivity	10	8
Electrical resistance	8	10
Contraction per ft. in casting (in.) ..	3/32	9/32
Crushing (1-in. cubes) (tons) ..	40	34

The heat-transmitting power of acid-resisting iron had been calculated at 10 times that of stoneware or quartz, and thus the parts could be made much smaller. A condenser built of acid-resisting iron condensed a charge of nitric acid in 16 hours, as against 36 hours with a similar condenser built of pottery. With all this success there were still difficulties to be overcome. All alloys of low-silicon content, say, 10 per cent., were attacked very readily by certain acids, and while acid-resisting iron which contained from 16 to 18 per cent. was satisfactory from the resistance to acid point of view, it was so very hard that it was impossible to machine it in any other way than by grinding with high-speed abrasives. Apart from chemical plant, this iron had a wide application for anodes in connection with electro-metallurgical processes. On the outbreak of the war it was impossible to obtain magnetite anodes, since these were chiefly made in Germany, and a substitute was found in acid-resisting iron. Whilst the material was not absolutely unacted upon when used for this purpose in copper sulphate solution, many times its original weight of copper could be deposited before the anode showed any serious signs of corrosion. The mechanical strength was a further considerable advantage, although a little higher electrical energy was required than with anodes made of magnetite.

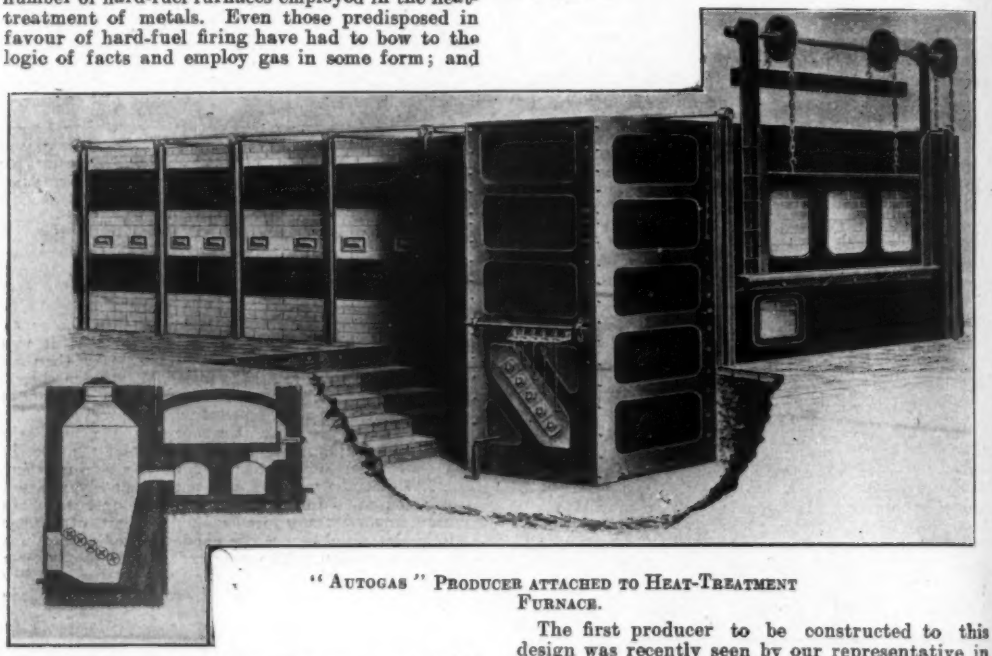
In the course of a discussion, CAPTAIN GOODWIN said there was a curious difference in the various makes of iron of this class. In the United States the silicon content was about 15 per cent., yet other manufacturers had 0.3 per cent. and another 2½ per cent. of manganese, and it would seem that better results would have been obtained if some of the manufacturers had employed chemists to advise them. There had been great difficulty in dealing with hydrochloric acid; so far as he was aware, only one alloy had been evolved which would stand that, and the silicon content in that case was from 16 to 20 per cent.

MR. J. W. HINCHLEY said there were some obvious faults in the comparison of physical constants given in the Paper. The figures for heat conductivity and electrical resistance were incorrect. The question of machining the material was not as hopeless as it might appear. It was possible with some brands, which had good acid resistance, to do some fairly satisfactory drilling and machining if the tools were properly chosen in the first instance.

MR. BANNISTER said a primary cause of failure in these metals was porosity, although sometimes this was quite minute and only discernible under microscopic examination. Another important point was the amount and nature of the graphite present. He had found castings behave perfectly well varying considerably in manganese from below 0.5 per cent. to 2 per cent.

"Autogas" Gas Producer.

Messrs. John Wright & Company, Essex Works, Birmingham, have, in the design of their "Autogas" producer, certainly made a considerable advance in the direction of fuel economy. It must now be recognised that we shall not for some years, if indeed ever again, have cheap fuel—that is as we understood the term in pre-war days. We are promised cheaper gas, but that at best is problematical; in any case, to make it possible a profitable market must be found for the resultant coke, and it is in this direction that apparatus of the type of the "Autogas" producer call for serious consideration. The necessity for speeding up and obtaining uniformity of output has been responsible for gas-fired furnaces displacing a very large number of hard-fuel furnaces employed in the heat-treatment of metals. Even those predisposed in favour of hard-fuel firing have had to bow to the logic of facts and employ gas in some form; and where gas has once been used there is small likelihood of any reversion back to hard fuel.



"Autogas" Producer attached to Heat-Treatment Furnace.

The "Autogas" producer, which we illustrate, has been designed for using ordinary gas coke, though obviously its possibilities are not confined to that material. It is certainly amongst the simplest of such apparatus. The main feature of the plant, as indeed in all producers, lies in the special form of the grate. The bars are of X section, with rounded ends which fit into bearings, and on one side of the furnace extend beyond those bearings and terminate in a square to which a hand lever can be applied to revolve the bars, each bar lying above and in front of the next one below it, the whole forming an upward-inclined grate. The lower portion of the back of the producer i inclined downwards and forwards.

The channels in the bars which are uppermost, for the time being, form reservoirs for water, of which each bar has its own independent supply, regulated by a separate valve and supplied from a ball-valve tank. This arrangement ensures a highly efficient water evaporation, and consequently the generation of a specially good quality of gas. As the bars are always maintained at a temperature of less than the boiling point of water their useful life is almost indefinite, and the intimate relation of the water and fuel prevents the formation of hard clinker. Periodically the bars are given a partial turn by means of the hand lever, thus bringing a fresh channel into position for the water and at the same time discharging the clinker and ash. The firebars are accessible by means of the large door shown in the front of the apparatus. The fuel is fed through the top door, the producer being arranged to take a charge sufficient for four hours on full duty. The producer works satisfactorily with a pressure of ½ in. w.g., so that with a chimney available no induced draft is required.

The first producer to be constructed to this design was recently seen by our representative in operation at the Tyne Glass Works, Gateshead-on-Tyne, where it was embodied in the brickwork of a melting furnace. The furnace chamber is 8 ft. by 3 ft. by 3 ft., and temperatures up to 1,400 deg. C. are easily maintained with a consumption of 1 cwt. of gas coke per hour. This furnace is worked on natural draft; the chimney, which is 60 ft. high by 2 ft. to 18 in. square, will, however, serve three further furnaces of similar size to the one in operation. To ensure freedom from dust within the furnace chamber, the gas, after leaving the producer, is led downwards through a conduit to a dust chamber furnished with a series of baffles, and from this chamber passes upward to the furnace. The air for regeneration is first led from back to front in the arching of the furnace down the front and beneath the furnace bottom. The total fuel consumption over the week-end to maintain the furnace sufficiently hot to protect the brickwork does not exceed 5 cwts. of coke.

It will be seen from our illustration that the producer is adapted for installation as an indepen-

dent section to supply a range of annealing or heating furnaces. The producers may be built to gasify from 56 lbs. of fuel per hour and upwards; in practice, however, it will be generally found better to duplicate the units rather than to employ a single unit to meet heavy requirements.

As an example of output for size, it may be mentioned that a producer with a grate area of 2 sq. ft. will gasify 1½ cwts. of coke per hour, whilst the same producer might be worked as low as 20 to 30 lbs. per hour.

Base-Metal Couples in Pyrometry.

Mr. C. M. Walter (Head of the Birmingham Corporation Gas Department Research Laboratory), at the recent meeting of the Birmingham Local Section of the Institute of Metals, read a Paper on "Pyrometry as applied to Works Practice," in which, after some introductory remarks, he stated that the earliest forms of couples employed consisted of junctions composed of platinum and palladium, and also platinum, platinum-iridium (10 per cent. Ir) and platinum, platinum-rhodium (10 per cent. Rh), the latter combination being first adopted by Le Chatelier owing to its greater stability at high temperatures. These combinations of metals had been successfully employed for the measurement of temperatures up to 1,400 deg. C., but owing to their high price junctions composed of less expensive metals and alloys were now frequently employed for measurements up to 1,000 deg. C. Such thermo-junctions were generally known as base-metal couples, and the combinations most usually adopted were iron-constantan, silver-constantan, and copper-constantan—constantan being a commercial alloy consisting of 60 per cent. copper and 40 per cent. nickel used for electrical resistance elements. Other junctions sometimes used were iron-nickel and nickel-nickel-chromium (10 per cent. Cr), the latter being known as the Hoskins couple. In the near future there would probably be still greater developments in the employment of such metals for thermo-electric pyrometry; in fact, he had information that some early and important developments might be expected. Describing the working of the thermo-electric couple, the author said that the electro-motive force produced by any thermo-couple depended on the difference of temperature between the two junctions, one being referred to as the "hot" and the other as the "cold" junction. The latter was generally at a temperature which could be independently measured and kept within some predetermined limits. For purposes of standardisation it was usual for the "cold" junction to be maintained at a temperature of 0 deg. C. As in practical use it was extremely difficult to maintain this temperature near a cold junction, various methods were adopted to ensure compensation for variation in temperature being obtained in the readings. As these methods involved the use of additional metal, they were far too costly when platinum-alloy couples were used in industrial practice, and other methods had to be resorted to. In some cases water cooling had been adopted, but perhaps from a practical point of view the most satisfactory system was the employment of Peake's compensating leads. Another method for keeping the cold junction at an even temperature was to bury it deep under the floor, and yet another to place it in oil in a thermos flask. Both methods have proved to be sufficiently good for most practical purposes.

In the course of the discussion which followed, Mr. F. C. A. H. Lantsberry said that base-metal couples had come to stay, and there were a great many in use at the present time. With regard to the protection of couples, the most common method in the past had been to place them in iron tubes, which had the disadvantage that it transformed the instrument into a crowbar or a poker, and it was often used as such. The experience of his friends has been that when the pyrometer was made to look like a delicate instrument it was treated in a delicate fashion.

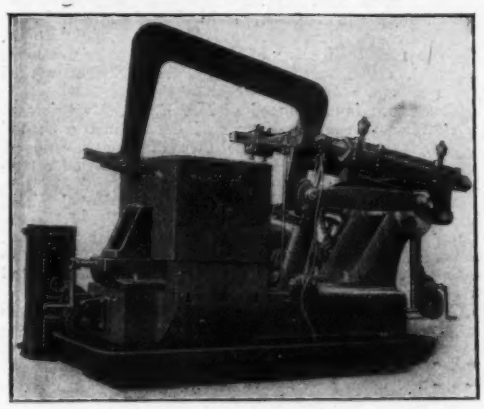
Mr. A. Astbury said, in his experience, a very successful method of dealing with the "cold" junction was to bury it 10 ft. below the floor, when the variation did not exceed 2 deg. throughout the whole year. Care should be taken to heat the "hot" junction to somewhere near the temperature of the metal bath before plunging it into the furnace.

Mr. Walter, replying to these and other speakers, said that in his department they had found a very effective method of overcoming to a great extent the difficulties in using base-metal couples, but they were not yet in a position to give details.

A Large Hack Saw.

The hack sawing machine illustrated herewith was specially designed and made for a gun factory by Messrs. Edward G. Herbert, Limited, Atlas Works, Levenshulme, Manchester. As it weighs 3½ tons and will saw through a billet of oil-hardened gun steel 26 in. square, it is by far the largest machine of this type at work.

The general design is similar to that of the "Rapid" sawing machines made by the same firm. The saw-frame is 3 ft. deep by 5 ft. wide overall



"Rapid" Hack Saw (Capacity 26 in. × 26 in.).

and takes blades from 24 to 39 in. in length by 2 in. wide. The main slide-bearing is 3 ft. 6 in. long and the main driving shaft is 3 in. diameter. The slide is pivoted on a separate shaft. The frame is counterbalanced by springs in the bed of the machine, and the pressure of the blade on the work is regulated by a worm gear and indicated on a dial. The frame can be raised and lowered by hand through worm gearing, which is put out of gear when cutting begins, and the feed is by gravity. The blade cuts on the outward stroke and is lifted from the work on the return stroke.

In the same factory there are five No. 3 motor-driven "Rapid" machines, dealing with work up to 15 in. diameter, which are engaged in sawing test pieces from oil-hardened gun tubes and jackets. All six machines are looked after by one unskilled man and a woman. Each machine is driven by a 3-h.p. variable-speed motor. Taking into account the low costs for power, labour and saw-blades, the management estimates that the cost of sawing through a 26-in. square billet on this machine is only about one-sixth of the cost of the method previously employed.

Deaths.

Mr. J. Whitehouse, a director of Brett's Stamping Company, Limited, Coventry, died recently at the age of 69 years.

The death is reported of Mr. W. J. Yarr, J.P., iron-founder, of Lapstone Road, Millom. The deceased was 78 years of age.

Mr. C. Cresswell, for many years general secretary of the Society of Chemical Industry, died recently at his residence at Ashtead, Surrey.

The death is announced of Mr. A. M'Onie, a well-known Glasgow engineer, formerly of the firm of Messrs. A. & T. W. M'Onie, Cessnock Engineering Works, Govan.

Mr. R. W. Hornsby, a director of Richard Hornsby & Sons, Limited, engineers, of Grantham, died recently in London. The deceased was the eldest son of the founder of the firm.

The death took place recently, at Ulverston, of Mr. John Dickinson, at the age of 80 years. For many years he was the manager of the North Lonsdale Iron Works, at Ulverston.

Major C. S. Lyon, M.C. (and bar), R.F.A., killed in action on March 21, was the son of the late James Lyon, Professor of Engineering in the Royal College of Science, Dublin.

Lieut.-Col. Elliott-Cooper, V.C., D.S.O., M.C., who has died in Hanover while a prisoner of war, was the son of Mr. R. Elliott-Cooper, engineer, of Deans Yard, Westminster, S.W.

The death took place, suddenly, last month, at his residence, Longfield, Rodley, of Mr. W. Booth, chairman and director of Joseph Booth & Brothers, Limited, crane makers, Rodley. Mr. Booth was 63 years of age.

The death is announced of Mr. F. W. Matthiessen, one of the pioneers in the zinc industry in the United States. He established the firm of Matthiessen & Hegeler, which became famous for its advanced metallurgical practice.

Captain (acting Major) G. F. Wolff, Royal Welsh Fusiliers, a son of the late Mr. Rudolf Wolff, of Messrs. Rudolf Wolff & Company, metal merchants, 147, Leadenhall Street, London, E.C., has been killed in action. Previous to the war Capt. Wolff represented the company in South America.

Captain Sydney Skelton (East Kent Regiment), who is reported as having died in Mesopotamia, is the fourth son of Mr. H. J. Skelton, well known in iron and steel circles as the head of the firm of H. J. Skelton & Company, Limited, of Royal London House, Finsbury Square, London, E.C.

The death occurred at Troon on April 20 of Mr. H. W. Smith, of the firm of Smith Brothers & Company, engineers, Kinning Park, Glasgow, who are well known as makers of machine tools. Mr. Smith was the last surviving member of the family of Mr. James Smith, one of the founders of the firm.

Major W. E. Furneaux, Seaforth Highlanders, was killed in action on March 24. He was the eldest son of the late Col. Furneaux, Durham Volunteer Engineers, and formerly of Clarke, Chapman & Company, Limited. Previous to the war, Major Furneaux was on the staff of the Stanley Steam Car, Limited, Gateshead.

Mr. R. B. Prosser, whose death in his 80th year is announced, was the eldest son of the late Mr. R. Prosser, a civil engineer in Birmingham. Mr. R. B. Prosser entered the Civil Service, and, removing to London, became chief examiner of patents at the Patent Office. He retired from that position some twenty years ago.

The death took place last month at Bolton of Mr. Andrew Little, who was well known in connection with the Cumberland iron trade. The deceased, who was 60 years of age, was formerly associated with the Old West Cumberland Works, then went to South Wales, and later became assistant manager under Mr. E. Carlisle at the Derwent Works at Workington.

The death took place on April 4 at Sheffield of Lieut. J. A. Sorby, Australian Field Artillery, a member of a well-known Sheffield family. Lieut. Sorby, who was 23 years of age, was a grandson of the late Mr. T. A. Sorby, of Park Grange, Sheffield. Prior to joining the Army he was associated with the Australian branch of the business of Messrs. B. K. Morton & Company, steel manufacturers, Prometheus Works, Sheffield.

The death has occurred of Mr. Godfrey Nettlefold, at his residence, Westfield House, near Arundel, at the age of 43. Mr. Nettlefold was a son of the late Mr. Edward John Nettlefold, and went to Birmingham as a young man, entering the business of Nettlefold & Company, Broad Street. He subsequently became a director, a position which he retained when the concern formed part of the amalgamated concern of Guest, Keen & Nettlefolds, Limited.

The death is announced of Mr. R. W. Blackwell, the founder and chairman of R. W. Blackwell & Company, Limited, and chairman of Johnson & Phillips, Limited. The deceased gentleman was born in 1858, but it was not until 1883 that he entered the engineering world by founding, with Mr. E. W. Bentley and Mr. W. H. Knight, the Bentley-Knight Electric Railway Company, of New York, the first of its kind to be operated on a commercial basis. He came to Great Britain in 1890, and shortly afterwards opened an office in London, in conjunction with Greenwood & Batley, Limited, for the purpose of introducing electric traction on to our tramway systems. Four years later he founded the firm of R. W. Blackwell & Company, who in subsequent years were connected with practically every electric traction scheme initiated.

Mr. L. F. Gjers, whose death took place recently at his residence, Busby Hall, Carlton-in-Cleveland, Yorkshire, was chairman and managing director of Gjers, Mills & Company, Limited, Ayresome Iron Works, Middlesbrough. The deceased gentleman, who was born in 1858, was an engineer first and an ironmaster afterwards. At King's College, London, he obtained a thoroughly sound training in scientific subjects which was of great advantage to him in after-life. From there he entered the engineering works of Messrs. Hopkins, Gilkes & Company, Middlesbrough, where he secured a practical training in engine construction, bridge-buiding, and general engineering. He spent two years with the well-known firm of analytical chemists, Messrs. Pattinson & Stead, Middlesbrough, and was found to be a man of keen intelligence and of great ability. He was probably one of the first to use carburised iron produced by melting steel scrap in a cupola, when it was necessary to increase the carbon without increasing the manganese. The metal mixed with spiegeliesen was run in a fluid condition direct from the cupola into the Bessemer converter. He then joined Mr. George Barrow for a short period on a geological survey of the Cleveland district. About that time the Darlington Iron Company decided to commence the manufacture of steel by the Bessemer process, to be worked in their rolling mills in conjunction with the iron they were then producing. They bought up the whole of the Bessemer plant which Bolckow, Vaughan & Company, Limited, were dismantling at their Gorton Works, near Manchester (their new steel works at Eston having then commenced operations), and installed it at Darlington. Mr. Gjers took a position at these works on the steel-making side, and obtained a great deal of valuable experience in the making of steel and its subsequent treatment. In the year 1883 Mr. Lawrence Gjers went to the Ayresome Iron Works to help his father in the management, but gradually took more and more responsibility until he was able to relieve his father of all the active work. Under his care the works were much improved, not so much in the general outlay of the plant, but in many improvements and additions, including labour-saving devices. For the last twenty years he has controlled the entire business, both commercial and practical, in a very skilful manner. As a blast-furnace manager he was most successful.

Trade Talk.

EVERED & COMPANY, LIMITED, have acquired the freehold of their Surrey works.

MESSRS. D. T. GRATTON & SONS, agricultural engineers, have removed to Boston.

THE MECHANICAL HAMMER COMPANY, LIMITED, have changed their name to Blacker, Limited.

THE offices of the St. Helens Smelting Company have been removed to 44, Mosley Street, Manchester.

MESSRS. K. ETTLINGER & COMPANY have removed to 251-258, Salisbury House, London Wall, E.C.2.

THE SUPERHEAT FURNACE COMPANY, LIMITED, have removed their registered offices to 21, Morley Street, Bradford.

WILLIAM COOKE AND COMPANY, LIMITED, have removed their London offices to 26, Victoria Street, Westminster, S.W.

THE price of cast-iron hollow-ware has been further advanced by 15 per cent. in consequence of the increased cost of wages and material.

A WINDING-UP order has been made against the British Huhn Metallic Company, Limited, 24, Basinghall Street, London, E.C.

THE CONSOLIDATED BRAKE AND ENGINEERING COMPANY, LIMITED, have removed to 15, Dean's Yard, Westminster, London, S.W.1.

AN order has been issued prohibiting the import of weighing machines, scales, and balances of all descriptions not otherwise prohibited.

SLIGHT damage has been caused by an outbreak of fire at the works of James Neill & Company, steel manufacturers, Napier Street, Sheffield.

THE KEIGHLEY GAS & OIL ENGINE COMPANY, LIMITED, have removed their London offices to Albion House, 59-61, New Oxford Street, W.C.1.

THE offices of the Columbia Steel and Engineering Company, Limited, have been removed to 334-6, Bank Chambers, 329, High Holborn, London, W.C.1.

THE PISTONLESS HYDRAULIC PRESS COMPANY, LIMITED, is being wound up voluntarily, with Mr. A. G. Morrish, 34 and 36, Gresham-street, London, E.C., as liquidator.

UNITED WATER SOFTENERS, LIMITED, have removed from Imperial House, Kingsway, to 20-22, Lincoln's Inn Fields, W.C.2, in consequence of the Government having commandeered their offices.

IT has been decided to voluntarily wind up the Union Engineering Company, Limited, for which purpose Mr. H. D. McAusland, 8, Victoria Street, Liverpool, has been appointed liquidator.

S. DIXON & SON, LIMITED, engineers, of Leeds, have removed their London offices to Walter House, 418-422, Strand, W.C.2, in consequence of the Government requiring their offices at Kingsway House.

CONSIDERABLE damage has been caused by a fire which occurred on April 19 at the Lion Works of Messrs. John Bedford & Sons, tool manufacturers, Mowbray Street, Sheffield.

SIR JOSEPH JONAS, COLVER & COMPANY, LIMITED, of Sheffield, have just put into operation a new 50-ton open-hearth steel furnace. A duplicate of this will be ready for starting up in the course of a few weeks.

MR. T. K. WILSON and Capt. A. K. Wilson have acquired the business of Sheffield Alloys, Limited, Northfield Works, Sheffield, and have changed the style of the firm to the Sheffield Alloy Steel Company, Limited.

THE creditors of the Rubel Bronze & Metal Company, Limited, have refused to accept the scheme of reconstruction submitted by the company, and call for an independent investigation into the affairs of the company.

THE MONOMETER MANUFACTURING COMPANY, LIMITED, is being wound up voluntarily, with Mr. H. T. C. S. Ledsam, 16, Waterloo Street, Birmingham, and Mr. G. G. Poppleton, 26, Corporation Street Birmingham, as liquidators.

MESSRS. G. H. THOMPSON and F. F. Adamson, pattern makers, etc., 1, Queen's Crescent, Sunderland, trading under the style of G. H. Thompson & Company, have dissolved partnership. Mr. Adamson will continue the business.

A RECEIVING ORDER has been made in connection with the affairs of Mr. C. Taylor, engineer and manufacturer, Nelson Road, Crouch End. The first meeting of the creditors took place on April 18, and the public examination on May 7.

MESSRS. J. STRETTON and J. Redgrave, metal casters and merchants, 197, Moseley Road, Birmingham, trading under the style of the Stretton Casting Company, have dissolved partnership. Mr. J. Stretton will continue the business.

THE COUNCIL OF THE WEST OF SCOTLAND IRON AND STEEL INSTITUTE propose to change the title of the Institute to the Iron, Steel and Metallurgical Institute of Scotland, and to extend the objects of the Institute to cover the iron, steel and metal industries.

THE ADVANCE MACHINERY COMPANY, 41, Lower Mosley Street, Manchester, have been appointed Lancashire and Cheshire agents for the Wild-Barfield electric furnaces and steel hardening equipment, made by the Automatic and Electric Furnaces, Limited.

THE members of the Chemical Industry Club have decided to form a social club for chemists, and those interested in chemistry, with a club house in London and with a town and country membership, the club to form the natural meeting-place for chemists in London.

IT is announced that holders of more than 80 per cent. of the shares of each class in the Workington Iron and Steel Company, Limited, have ratified the provisional agreement for amalgamating with Steel, Peech and Tozer, Samuel Fox & Company, and the Rother Vale Collieries.

A MOVEMENT is on foot in America to abolish the designation German silver, and to substitute the name "nickel silver." The American Brass Company, one of the largest producers of this metal, was the first concern in the States to adopt this suggestion. The change has already been made in this country.

THE CONSTRUCTIONAL ENGINEERING COMPANY, of the Titan Works, Charles Henry Street, Birmingham, are supplying to a Government Department a complete foundry plant, consisting of twin set of cupolas, charging platform, hoist fans, etc. This is to be erected at one of the War Office Experimental Stations.

THE processes of crushing, grinding, and sieving of refractory materials, and any processes involving the manipulation of such materials in the manufacture of bricks or other articles, have been certified to be dangerous. The Home Secretary will shortly issue regulations to apply to all factories and workshops in which the processes are carried on.

WITH regard to Norwegian molybdenite, it is reported that Mr. Tormod Forland, an engineer of Haugesund, has invented a new method for the production of ferro-molybdenum, ammonium molybdate and other molybdenum products. The process is said to be a chemical and electrolytic one, and avoids the great loss of molybdenum which is incident to the usual electro-thermic methods.

FRICKER'S METAL COMPANY, LIMITED, is being voluntarily wound up with a view to its reconstruction, and Mr. H. E. Carey, 53, Cardiff Road, Luton, has been appointed liquidator. A new company is being registered under the name of Fricker's Metal Company, Limited, with a capital of £30,000, in £1 shares. A meeting of the creditors of the company will be held at the Langley Metal Works, Luton, on April 3.

ATTENTION is drawn in the report of the Iron and Steel Trades Confederation to the developments taking place in the use of the electric furnace in steel production. It is estimated that there are 160 of such furnaces in this country, of which 131 are working and 29 in the course of construction. But for the Government refusing to allow further installations, except on licence, the number would probably have been much greater.

Replying to Mr. Joynson-Hicks, last month, MR.

DUDLEY WARD said that the business of the London Emery Works could not be disposed of until an action against the Controller for specific performance of an agreement for the sale of the business had been heard. Pending the determination of the case, the Ministry of Munitions had been requested to allocate supplies of emery stone to the business, but not in preference to other businesses.

THE EAST COAST STEEL CORPORATION, LIMITED, one of the companies in the group which have Lord Furness at their head, have acquired the extensive foundries, blast furnaces, ironstone mines, and collieries belonging to Messrs. Cochrane & Company, of Middlesbrough. The firm are large producers of cast-iron pipes, and their name is widely known. Hitherto they have been a private firm. The amount they are to receive for the business has not been disclosed.

THE Ithaca laboratory of the U.S. Bureau of Mines has studied the problem of producing ferro-uranium. Uranium-oxide having been produced as a by-product in the radium co-operative work of the Bureau and the National Radium Institute, the best method for the utilisation of this uranium was sought. It is understood that uranium steel has recently found use abroad. The results of the investigations undertaken by the Bureau has been published as a technical paper.

THE secretary of the Decimal Association announces that at the annual meeting of the Associated Chambers of Commerce a motion was passed urging the Government to pass into law the Decimal Coinage Bill prepared by the executive council of the Associated Chambers of Commerce in conjunction with the Institute of Bankers and the Decimal Association. It is understood that Lord Southwark will introduce the Bill into Parliament at the earliest possible moment.

OUR PARLIAMENTARY CORRESPONDENT learns that the Decimal Coinage Bill, which is being introduced in the Upper House by Lord Southwark, provides for the abolition of the existing silver, copper, and bronze coins, their places being taken by coins, each of which would be a thousandth part or the multiple of a thousandth part in value of the sovereign. The new coins would consist of double florin, florin, half-florin, and quarter florin in silver, a ten and a five mil piece in nickel or other metal or alloy, and a four, three, two, and one mil piece in bronze.

THE electric furnaces at Belleville in Canada have been occupied during 1917 with the production of ferro-molybdenum from molybdenite concentrate. This process has now been adopted at Orillia in place of the less direct chemical process which was formerly in use. The production of "stellite," an alloy of cobalt, chromium and tungsten, is affording a new use for cobalt. The whole subject of the production in Canada of ferro-alloys, such as ferro-manganese, ferro-chrome and ferro-tungsten, will be discussed at the annual meeting of the Canadian Mining Institute.

FOR the past thirty years, unknown to the scientific and engineering world, in which, as the inventor of the steam turbine and other devices, he is so famous, the Hon. Sir Charles Parsons has been conducting experiments on the formation of the diamond. The results of his work in this fascinating field of research were made known for the first time at the eighth annual May lecture which he gave before the Institute of Metals on May 2. In view of the special character of the occasion, the Council of the Institute of Metals decided to make this an open meeting.

THE annual meeting of the Liverpool Engineering Society was held on April 24, the President (Mr. Harold Dickinson) occupying the chair. The report showed a membership of 595. The financial position of the society was satisfactory. Professor J. Wemyss Anderson was elected president for the ensuing year, and Mr. J. Hamilton Gibson, and Lieut.-Colonel J. R. Davidson, vice-presidents. Afterwards a lecture on "Photo-Micrographic Examination of Metals" was delivered for Mr. R. Croston, secretary of the Liverpool Microscopical Society.

A LETTER has been received by the manufacturers of brass rods in Birmingham from Sir Leonard Llewellyn, Controller of Non-Ferrous Material Supply to the Ministry of Munitions, in which he states:—"Owing to the present decreased demand for brass rods, it is desirable that all night shifts that may still be employed, either in foundries or rod-mills, should be discontinued for the time being. Will you kindly inform me whether you are at the present moment employing night shifts, and if so what number of men or women would be released by cessation, also by what amount your output would be reduced?"

THE business of Schaffer & Budenberg, Limited, Broadheath, near Manchester, has now become entirely a British undertaking, and the name of the company has been changed to the Budenberg Gauge Company, Limited. Mr. C. F. Budenberg, who has been the manager of the business for the past twenty-nine years and managing director since the company was incorporated in 1902, has purchased all the issued shares. Mr. Budenberg will continue to act as managing director, and Mr. R. M. Chiswell and Mr. R. H. Jackson, both of whom have been connected with the business for many years, will be associated with him as directors.

THE Metal Merchants Section of the London Chamber of Commerce has passed a resolution approving "the appointment of a committee to confer with members of Parliament with a view to constantly raising questions of interest to the trades concerned in the House of Commons." For some time the London Chamber of Commerce has been pressing the Government as to the serious effect Government trading has on the nation and the effective conduct of the war, and at the meeting of the Association of Chambers of Commerce of the United Kingdom last month a resolution was passed which indicated that they viewed with apprehension the methods adopted by the Government in connection with the control of trade and industry.

BY a Proclamation issued on April 12 the undernoted amendments have been made to the list of prohibited exports:—Headings deleted:—(A) Castings, malleable, hematite iron, the following—motor cycle fittings; (c) motor vehicles, motor bicycles, and their component parts and accessories, not otherwise prohibited; (c) oil, blast furnace; (b) tin, manufactures of (except hollow-ware, tinplates, and receptacles made from tinplates); (A) tinplates, and receptacles made from tinplates. Headings added:—(A) Bedsteads, metal, and metal frames for bedsteads; (A) bins, iron or steel; (A) buckets, iron or steel; (A) cobaltchrom and similar alloys; (A) motor vehicles, motor bicycles, and their component parts and accessories; (A) oil, blast furnace; (A) stellite and similar alloys; (b) tin, manufactures of (except hollow-ware, tinplates, and receptacles made wholly or partly from tinplates); (A) tinplates and receptacles made wholly or partly from tinplates; (A) tubs, washing, iron or steel.

A SCHEME of reorganisation has been decided upon by the Birmingham Brassmasters' Association. After the war many problems affecting the relationship of capital and labour will doubtless arise, while the Board of Trade are anxious to enter into communication with associations rather than individuals, with regard to the supplying of information received from the commercial attachés. To meet these requirements the Brassmasters' Association recently applied for an organiser, but failed to make a suitable appointment, and Mr. J. W. Madeley, a director of United Brassfounders and Engineers, Limited, was then approached by a large section of the trade, and requested to undertake the duties. Mr. Madeley, who has been connected with the association for 25 years, and has been chairman of the association and of the conciliation board for six years, has consented to take the office. He proposes to give up the whole of his business connections and to devote his time entirely to the service of the association in the attempt to improve the general conditions of the brassfoundry trade. The association has been requested by the Priorities Committee to undertake the rationing of materials necessary to the brass trade.

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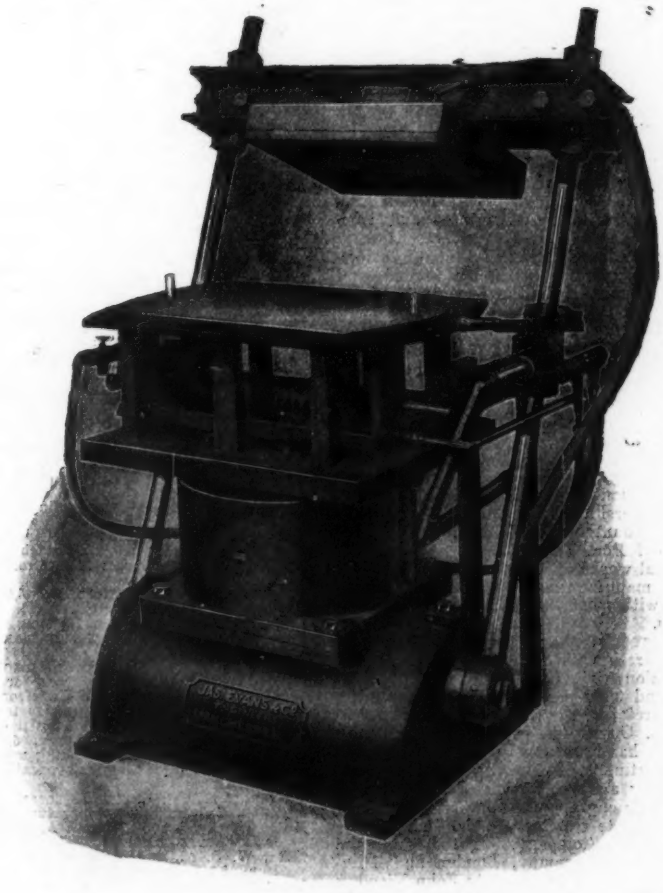
Pneumatic, Hydraulic, Jar Ramming, & Hand Power.



JAMES EVANS & CO., BRITANNIA WORKS,

BLACKFRIARS, MANCHESTER.

Personal.

DR. H. C. H. CARPENTER, Professor of Metallurgy at the Royal School of Mines, has been elected a Fellow of the Royal Society.

COL. WM. SIDEBOTTOM, deputy-chairman of Cammell, Laird & Company, Limited, has decided, on account of his advancing years, to resign.

THE gross value of the estate of the late Sir John Wolfe Barry, K.C.B., is £278,362, including net personalty of the value of £225,033.

MR. J. BOURN has resigned the position of general manager of the Tyne Iron Shipbuilding Company, Limited, of Willington Quay-on-Tyne.

CAPT. ELGIN NEEDHAM, Machine Gun Corps, missing, is the son of Mr. G. W. Needham, of Oldham, chairman of Platt Brothers & Company, Limited.

CAPT. W. E. J. LEWIS, who is suffering from gas-poisoning and shell-shock, was previously assistant-manager at the Siemen's furnaces at Ebbw Vale.

THE gross value of the estate of the late Mr. J. Carter, managing director of Carter Bros. (Rochdale), Limited, engineers, millwrights, and ironfounders, is £7,130.

SIR GEO. J. CARTER, managing director of Cammell, Laird & Company, Limited, is reported to have resigned his position in the Admiralty Shipbuilding Council.

ESTATE of the gross value of £32,895 has been left by the late Mr. J. Jones, of Britannia House, Loughborough, Leicester, retired engineer and ironfounder.

MR. R. RAMAGE, senior director of Ramage & Ferguson, Limited, shipbuilders, Leith, has retired, and has disposed of his interest in the firm to Sir John Ellerman, Bart.

THE late Mr. J. Lawley, J.P., of West Bromwich, Staffs, a director of W. & J. Lawley, Limited, ironfounders, left estate valued at £20,864 gross, of which £16,576 is net personalty.

CAPT. A. BAKER, M.C., York and Lancaster Regiment, a member of the firm of John Baker & Company, Limited, steel manufacturers, Rotherham and Kilnhurst, has been wounded.

MR. C. L. FAULKNER, of Suffolk House, Laurence Pountney Hill, Cannon Street, London, E.C.4., has entered into partnership with Messrs. Bolling & Lowe, 2, Laurence Pountney Hill, E.C.4.

MR. J. HAYES, of Port Talbot, has been appointed manager of the local works of Vivian & Sons, Limited, copper and brass manufacturers, as successor to the late Major Bray, with whom he was closely associated for about 30 years.

MR. W. A. TOOKEY has been compelled, owing to professional duties, to resign his position as secretary of the Junior Institution of Engineers, but will continue as hon. secretary and treasurer. Mr. H. G. Riddle has been appointed secretary.

MR. ALAN E. L. CHORLTON, of Ruston, Proctor & Company, Limited, has been appointed Assistant-Controller of the Department of Aircraft Production, to deal with the supply and production of aero engines, excluding Rolls-Royce engines.

MR. F. K. COOKE, late secretary to the Unbreakable Pulley & Mill Gearing Company, Limited, and the Cooper Roller Bearings Company, London and Manchester, has been appointed secretary to John Wood & Sons, Limited, of the Barley Brook Foundry & Engineering Works, Wigan.

MAJOR ALAN STEIN, Argyll and Sutherland Highlanders, attached Gordon Highlanders, a director of John G. Stein & Company, Limited, silica and firebrick works, Bonnybridge and Castlecary, has been the recipient of a presentation from the employés of the firm in recognition of his having gained the Military Cross and bar for conspicuous and gallant service in connection with operations in the field. Major Stein is the eldest son of Mr. John G. Stein, and, in addition to his seat on the board, is secretary of the company.

COL. GALLOWAY recently resigned his position as a director of the Carnforth Hematite Iron Company, Limited, and Mr. F. J. Dickens, Mr. T. S. Peacock, and Mr. F. H. Poole were elected to the board. Since the January meeting, however, a controlling interest in the company has been acquired by steelmaking firms, who are amongst the oldest users of Carnforth iron. In view of this arrangement the directors named have agreed to retire from the board, and the following, who are associated with the steelmakers referred to, offer themselves for election :—Sir William Ellis (John Brown & Company, Limited), Sir Thomas Putnam (The Darlington Forge Company, Limited), Mr. A. W. Dixon, Mr. A. J. Grant, and Mr. Reginald Pease.

Applications for Patents.

Ash, J. J. Electric arc furnaces. 4,841. March 19.
Ashcroft, E. A. Manufacture of chemically-reactive alloys. 6,581. April 15.
Ashcroft, E. A. Manufacture of oxides or salts of tungsten or of metallic tungsten from substances containing tungsten. 6,646. April 17.
Ashcroft, E. A. Manufacture of oxides or salts of metals, or of metals, or of non-metals from ores, minerals, intermediate products, residues, wastes, etc. 6,547. April 17.
Ashcroft, E. A. Manufacture of aluminium or its oxides or salts from materials containing aluminium. 6,548. April 17.
Ashcroft, E. A Manufacture of silicon chloride and removal of silica from fused melts. 6,549. April 17.
Atkinson, J. S., and Stein & Atkinson. Stripping ingots. 5,855. April 5.
Bingham, C. Apparatus for heating air blast for iron and steel furnaces. 4,385. March 13.
Brayshaw, E. R. and S. N. Gas-fired furnaces for metallurgical, etc., purposes. 4,797. March 19.
Bradshaw, R. G. Rotary moulding machine. 5,593. April 2
Brayshaw, E. R. and S. N. Burner for gas-fired furnaces. 4,812. March 19.
Brookfield, D., Tylor & Sons, and Gaunt, J. Means for superheating charge in crucible, etc., furnaces. 5,095. March 22.
Brookfield, D., Tylor & Sons, and Gaunt, J. Means for tilting crucible furnaces. 5,152. March 23.
Brookes, W. A., and Parr, A. H. Cast-iron moulds for metal casting. 5,340. March 27.
Colee, S. O. Cowper-. Process for rendering aluminium and its alloys more durable. 5,710. April 3.
Cressey, R. H., and W. B. Process for recovery of metals from dross, skimmings, etc. 5,901. April 6.
Davies, E. W. Moulds for casting metal ingots, etc. 5,426 March 22.
Downes, G. A. Furnaces for melting metals. 5,948. April 8.
Duffus, R. Foundry moulding machines. 4,989. March 21.
Estelle, A. T. C. Process of electrolytically producing iron. 5,398. March 27.
Fleming, J. A. Electric furnaces. 5,039. April 9.
Forrester, G. H. Melting tin. 5,696. April 3.
Ghijsen, H. C. Smelting furnaces with means for intermittently cutting off molten mass delivered therefrom. 6,057. April 9.
Ghijsen, H. C., and Naamlooze Vennootschap Vitrite Works. Smelting furnaces with means for intermittently cutting off molten mass delivered therefrom. 6,057. April 9.
Gontermann, W. Thomas process for production of steel. 5,811. April 4. (Germany, April 4, '17.)
Greaves, H. A. Electric furnaces. 6,563. April 18.
Harrison, W. Snap-flask moulding machine. 6,095. April 10.
Harvey, L. C. Annealing and reheating furnaces, etc. 6,119. April 10.
Lawton, T. A. D. Electric furnaces. 6,660. 6,661. April 19.
Macbeth, C. Moulding apparatus. 4,947. March 20.
Mate, W. C. A., and Poulson, A. Treatment of moulds for making metal castings. 4,779. March 19.
Mate, W. C. A., and Poulson, A. Production of malleable iron. 5,347. March 27.
Morgan Crucible Co. and Harvey, L. C. Crucible melting furnaces. 4,682. March 16.
Oubridge, W. A., and Williams, G. Producing centrifugal castings in moulds. 6,027. April 9.
Potti, L. C. Producing centrifugal castings in moulds. 6,027. April 9.
Reynolds, A Production of steel. 4,767. March 18.
Richard, J. B. Making cast-iron, etc., barges, ships, etc. 4,439. March 13.
Scottish Central Iron Company. Snap-flask moulding machine. 6,095. April 10.
Vereinigte Hüttenwerke Burbach-Eich-Düdelingen Act.-Ges. Production of metallic alloys. 6,274. April 12. (Germany, June 23, '16.)
Weir, E. W. Manufacture of malleable iron castings. 4,239 March 11.

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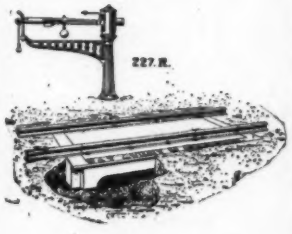

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New Companies.

Phillips Engineering Company, Limited. — Capital £5,000, in £1 shares.

Aeronautical Engineering Company, Limited.—Capital £20,000 in £1 shares.

Robin Hood Oxide & Iron Company, Limited.—Capital £50,000 in 2s. shares.

Oughtibridge Silica Firebrick Company, Limited.—Capital £200,000 in £1 shares.

Richford & Company, Limited.—Capital £8,000 in £1 shares, to carry on the business of ironfounders.

Child & Hewitt, Limited.—Capital £5,000 in £1 shares, to carry on the business of hardware merchants.

Small Tool Supply Company, Limited. — Capital £2,000 in £1 shares. The first director is E. V. Varley.

T. Inman & Company, Limited.—Capital £50,000 in £1 shares, to carry on the business of steel manufacturers.

Arthur R. Price (Aston Manor), Limited. — Capital £15,000 in £1 shares, to carry on the business of brassfounders.

Express Engineering Works, Limited. — Capital £10,000 in £1 shares. Registered office: 7, Great St. Helens, E.C.

Adjustable Tools, Limited. — Capital, £1,000 in £1 shares. Registered office: Lorna Works, Fitzroy Street, Ashton-on-Mersey.

Oaklands Engineering Company, Limited. — Capital £1,000 in £1 shares. Registered office:—17, Basinghall Street, E.C.2.

Cartvale Engineering Company, Limited.—Capital £1,500 in £1 shares. Registered office:—61, New Sneddon Street, Paisley.

L. S. Starrett Company (Great Britain), Limited.—Capital £60,000 in £1 shares, to carry on the business of tool manufacturers.

City Brass Casting Company, Limited. — Capital £5,000 in £1 shares. Registered office: 4, Moncrieff Lane, off Oxford Street, Glasgow.

National Metal & Chemical Bank, Limited.—Capital £1,000,000 in 100,000 shares of £10 each. Registered office:—70, Lombard Street, E.C.

North Finchley Motors & Metals, Limited.—Capital £5,000 in £1 shares. Registered office:—15, Woodhouse Parade, North Finchley, N.12.

Acre Steel Company, Limited.—Capital £10,000 in £1 shares (5,500 preference and 4,500 ordinary). Registered offices:—57-9, Long Acre, W.C.

Jacob & Partners (Port Talbot), Limited.—Capital £40,000 in £1 shares, to carry on the business of ironfounders, mechanical and electrical engineers, etc.

Mears & Stainbank, Limited.—Capital £10,045 in 10,000 preference shares of £1 each and 900 ordinary shares of 1s. each, to carry on the business of bellfounders.

James Chew & Company, Limited.—Capital £25,000 in £1 shares, to carry on the business of brassfounders. Registered office:—Brookhouse Works, Edward Street, Blackburn.

John Finlay & Company, Limited.—Capital £7,000 in £1 shares, to carry on the business of founders of iron, brass, steel, etc. Registered office:—18, Renfield Street, Glasgow.

Milne & Robb, Limited.—Capital £2,500 in £1 shares, to acquire and carry on the business of an engineer, carried on by Alex. Milne. Registered office: 15, Seagate, Peterhead.

Rickerby, Limited.—Capital £6,000 in £1 shares, to take over the business carried on at Carlisle by J. Rickerby, engineers, etc. Registered office:—33, Botchergate, Carlisle.

Robert Melvin, Limited. — Capital £10,000 in £1 shares, to acquire the existing business of engineering and ironfounding. Registered office: Sunnyside Foundry, Greenfield Street, Alloa.

Attercliffe Engineering & Tool Company, Limited.—Capital £2,000 in £1 shares. The first directors are W. Allen and A. F. Ledger. Registered office:—Ardmore Street, Attercliffe, Sheffield.

F. W. Harris (Birmingham), Limited.—Capital £20,000 in £1 shares, to take over the business of a metal merchant and manufacturer carried on by F. W. Harris at 132-4, Hurst Street, Birmingham.

Richford & Company, Limited.—Capital £8,000 in £1 shares, to take over the business of iron and brass founders, etc., carried on at the Milner Works, Barnsbury Street, Islington, N., as Richford & Company.

Metropolitan Associated Engineers, Limited.—Capital £3,000 in £1 shares, to take over the business carried on by E. Blunt at 65, Camden Road, London, as the Camden Associated Engineers. Registered offices: 65, Camden Road, N.W.1.

London Metallic Waste, Limited.—Capital £60,000 in £1 shares, to enter into agreements with E. Mandeville, A. Cohen, and the Metallic Waste (Parent) Syndicate, Limited. The first directors are E. Mandeville and A. Cohen. Registered office: 18, Regent Street, S.W.

H. Llewellyn Dent, Limited.—Capital £50,000 in £1 shares (30,000 preference), to carry on the business of constructional, electrical, mechanical, sanitary, civil, railway, consulting, and general engineers, etc. Registered office:—Hadyn Park Works, Shepherd's Bush, W.12.

United Steel Companies, Limited.—Capital £7,680,000 in £1 shares (1,330,000 original preference and 6,350,000 ordinary), to acquire the preference and ordinary shares of Steel, Peech & Tozer, Limited, Samuel Fox & Company, Limited, the Frodingham Iron & Steel Company, Limited, the Appleby Iron Company, Limited, the Workington Iron & Steel Company, Limited, and the Rother Vale Collieries, Limited, and to enter into an agreement with the Imperial & Foreign Corporation, Limited. The first directors are Mr. Hy. Steel, Doncaster; Mr. Wm. Steel, Cotefield, near Sheffield; Mr. Wm. Tozer, Sheffield; Mr. A. O. Peech, Rotherham; Mr. J. Peech, London; Mr. W. Chesterman, Sheffield; Mr. H. Barber, Sheffield; Mr. F. S. Scott-Smith, Barnsley; Mr. F. J. Jones, Grantham; and Mr. W. Benton-Jones, Rotherham.

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SILICO-MANGANESE {**23/30** % Silicon. **65/70** % Manganese and **1** %, **2** %, **3** %, Carbon Maximum.

FERRO-SILICON Containing **25** %, **50** %, **75** % Silicon.

FERRO-CHROME **65/70** % Cr. & **1** % up to **8/10** % Carbon Maximum.

MAGNESIUM METAL **99** %. *In Sticks and Powder and Magnesium Copper.*

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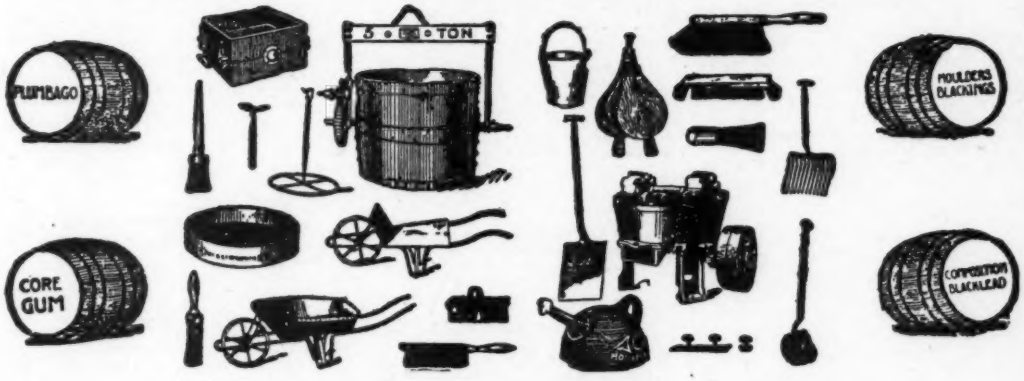

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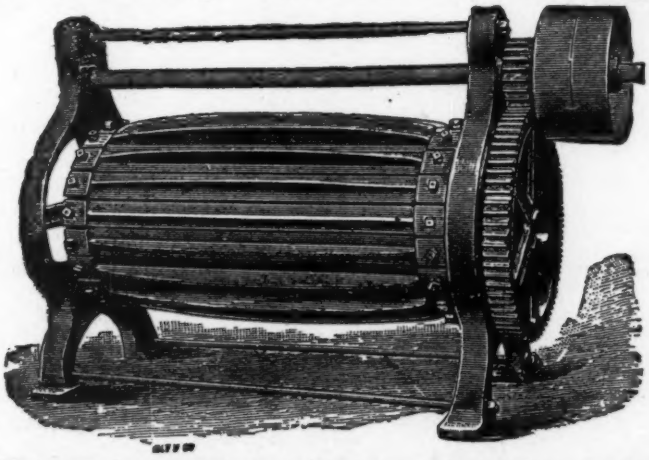
Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



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The undermentioned prices, unless otherwise specified, are those obtaining at the commencement of the current month.

CONTROL PRICES.

Pig-Iron.

	£	s.	d.
West Coast hematite, mixed Nos. 1, 2 and 3	6	7	6
Special under 0.03 P. & S.	6	15	6
„ „ 0.02 „	7	0	0
East Coast hematite, mixed Nos. 1, 2 and 3	6	2	6
Special under 0.04 P. & S.	6	7	6
Special under 0.03 P & S.	6	15	6
„ „ 0.02 „	7	0	0
Scotch hematite, mixed Nos. 1, 2 and 3	6	2	6
Special under 0.03 P. & S.	7	10	0
Welsh hematite, mixed Nos. 1, 2 and 3	6	2	6
Special under 0.03 P. & S.	6	15	6
„ „ 0.02 „	7	0	0
HEMATITE—MALLEABLE— Refined—			
Refined Cupola Cast	8	0	0
Refined Cupola Cast to guaranteed analysis	8	5	0
Cast direct from Blast Furnaces—			
Small Pig-Iron, all grades	7	10	0
Medium Pig-Iron White to Grey mottled	7	5	0
Medium Pig-Iron, all other qualities	6	17	6
Large Pig-Iron, all grades	6	17	6
Lincolnshire, basic or foundry	4	17	6
Cleveland, No. 1	4	19	0
„ other grades	4	15	0
„ basic	5	0	0
Northamptonshire, forge	4	7	6
„ fdy numbers	89/0		94/0
„ basic	4	17	6
Derbyshire, forge	4	10	0
„ foundry numbers	92/6		96/6
Derby & Notts. basic.	4	17	6
Leicestershire & Notts., forge	4	10	0
„ „ foundry nos.	92/6		96/6
North Staffs, forge	4	15	0
„ „ foundry	4	17	6
„ „ basic	4	17	6
South Staffordshire— Part mine forge	5	0	0
„ foundry	5	2	6
Common Staffordshire	4	15	0
All mine forge	5	15	0
„ foundry	6	0	0
Warm air forge	7	5	0
„ foundry	7	15	0
Lord Dudley's silicon	8	7	6
Cold blast	9	2	6
Basic	4	17	6
Scotch foundry and forge— Nos. 3, 4, and lower grades of Monkland, Dalmellington, Eglinton, and Govan	5	14	0
Nos. 3, 4, and lower grades of all other brands	5	15	6

No. 1 quality in all cases to be 5s. per ton above these prices.

All per ton net, f.o.t. makers' works. Mers. Com. 1½%

In all districts 1s. extra may be charged for Basic cast in chills.

High-Speed Tool Steel.

The maximum prices for high-speed tool steel have been fixed as follows:—

Finished bars, 14% Tung. 3s. 8d.

Finished bars, 18% Tung. 4s. 5d.

Per lb. basis. Extras as per authorised list. These prices are net delivered buyers' works.

The fixed prices for scrap which must be returned to steel makers' works are as follows:—

Millings and Turnings .. .. 8d.
Bar Ends .. .. 9d.

Both per lb. net delivered steel makers' works.

Ferro-Alloys

Net, Delivered Sheffield steel works.

	£	s.	d.
Ferro chrome: 4/6% carbon. Basis 60%, scale 10s. per unit Per ton		—	
Ferro-chrome: 6/8% carbon. Basis 60%, scale 10s. per unit. Per ton		—	
Ferro-chrome: 8/10% carbon. Basis 60% scale, 10s. per unit Per ton		—	
Ferro-chrome: Specially refined, guaranteed maximum 2% carbon broken to small pieces for use in best quality crucible steels. Basis 60%, scale 32s. per unit. Per ton		—	
Ferro-vanadium: 33/40% Va., per lb. of Va. contained in the alloy		—	
Ferro-silicon: 45/50%. Basis 50%, 5s. scale per unit Per ton		—	
Ferro-titanium: 23/25%, per lb. carbonless		—	
Ferro-molybdenum: 70/80% Mo. per pound of Mo. contained		—	
Ferro-phosphorus: 20/25%. Per ton		—	
Ferro-tungsten: 75% to 80% per lb. of metallic tungsten contained		—	
*Ferro-manganese 80%	26	10	0
„ export	—	—	

* F.o b. Liverpool.

Non-Ferrous Metals.

Copper.

	£	s.	d.	£	s.	d.
Standard, Cash	110	0	0	110	10	0
Three months	110	0	0	110	10	0
Electrolytic	125	0	0	121	0	0
Tough	123	0	0	119	0	0
Best selected	123	0	0	119	0	0

Tin.

Standard, Cash	360	0	0	—
„ Three months	360	0	0	—
English Ingots	369	0	0	—
Bars	370		0	—
Refined		—		—

Spelter.

American	54	0	0	50	0	0
Specials		—			—	
Hard	45	0	0	46	0	0
British	56	10	0	57	0	0

Lead.

Soft Foreign (net)	29	10	0	28	10	0
English		—			Nom.	

Antimony.

Regulus		—		85	0	0

Aluminium.

Virgin Metal 98/99% per ton	—

Phosphor Bronze.

INGOTS.	Per ton.
Alloy No. I. or II	—
III., IV. or V.	—
VI. or VII.	—
VIII.	—
XI.	—
Cast Strips and Ingots	—

CASTINGS.	Per lb.
I. or II.	—
III. IV. or V.	—
VI. or VII	—
VIII.	—
XI.	—
No. VII., Chill, Cast, Solid	—
„ Cored Bars	—

Delivery 2 Cwt. free to any town.

10 per cent. Phosphor Copper .. £50 above price of best selected copper.

15 per cent. Phosphor Copper .. £70 above price B.S.

Phosphor Tin (5 per cent.) .. £30 above price of English Ingots.

(Phosphor-bronze prices supplied by CHARLES CLIFFORD AND SON, LIMITED, FAZELEY STREET MILLS, BIRMINGHAM)

***Chromium (Metallic).**

98/99% purity, per lb. — —

***Nickel.**

In cubes, 98/99% purity Per ton —

Nickel Silver.

	per lb.
Ingots for raising	—
Ingots for Spoons and Forks	—
„ rolled to spoon size	—

***Tungsten Metal Powder.**

96/98% purity.. per lb. —

***Molybdenum Metal.**

96/98% purity.. per lb. —

***Cobalt Metal.**

97% purity .. per lb. —

Quicksilver.

75 lb. bottle —

* Net, Delivered Sheffield Works.

Scrap Iron and Steel.

Cleveland.

	s.	d.	s.	d.
Steel scrap, heavy melting	—		—	
Iron scrap cast (cupola metal)	—		—	

London (f.o.b.).

Heavy steel	105	0
Light „	55	0
Heavy cast	95	0

Control Prices.

Heavy Steel Melting Scrap 105	0	125	0
Steel Planings, Turnings and Borings	65	0
Steel Planings, Turnings and Borings mixed with Wrought Iron, &c.	50	0
Steel Scrap, all other Classes	95	0
Wrought Iron Scrap	125	0
Ditto, mixed with Steel	95	0
W.I. Planings, Turnings and Borings mixed with Steel, &c.	50	0

Per ton delivered Buyers' Works.

Non-Ferrous Scrap.

London merchants quote the following prices for scrap metal, delivered London, and subject to market fluctuations:—

	A. Joseph. £	s.	d.
Hy. Electrolytic Copper Scrap		—	
Hy. Selected Scrap Brass		—	
Hy. Tinned Copper Wire		—	
Best Selected Gunmetal Scrap		—	
Re-melted Ingot Lead		—	

Stocks.

Metals.

	Tons.
Copper, Europe and afloat	—
Tin, London, Holland, U.S.A. and afloat	20,463

Coke.

Middlesbrough.

	s.	d.	s.	d.
Gas Coke	32	6	—	
Foundry	45	0	—	

Glasgow.

Foundry Coke	—		45	0
Furnace Coke	35	0	—	
Gas Coke	—			

London.

Welsh or Durham Foundry, d/d London Stations in truck	45	0	53	0
Ditto, d/d Birmingham Stations	44	0	48	0
Yorkshire, d/d London Stations, in truck	42	6	—	
Ditto, d/d Birmingham Stations	39	6		

CONTROL PRICES OF COKE.

	s.	d.
Durham and Northumberland blast furnace	33	0
„ foundry	38	0
Yorkshire, Lancashire, Staffordshire, Notts., Derbyshire, Lincs, & Midland Counties blast furnace	32	0
South Wales blast furnace	37	6
„ foundry	50	6

All per ton net. f.o.t. ovens.

Cumberland blast furnace 37 9
d/d West Coast furnaces

SITUATIONS VACANT AND WANTED.

MOULDERS wanted in Iron and Brass Foundry—West London.—Box V. S., Messrs. E. J. Reid & Co., 49, Watling Street, London, E.C.4.

FOREMAN required for small Brass, Aluminium and Manganese Bronze Foundry. Applicants must have had previous experience in mixing of metals. No person already on Government work will be engaged.—Apply, stating age, experience, and wages required, to your nearest Employment Exchange, quoting No. A. 5109.

WANTED, Steel Castings MOULDER, familiar with metal mixings. Must be reliable man and able to take charge.—Box 948, Offices of the Foundry Trade Journal, 165, Strand, London, W.C.2.

IRONFOUNDERS.—Qualified Chemist, with well-equipped private Laboratory, is open to receive samples of Iron, Steel, Fuels, etc., for analysis. Accuracy and promptness guaranteed.—Apply, Box 954, Offices of the Foundry Trade Journal, 165, Strand, London, W.C.2.

FOUNDRY MANAGER WANTED.—First-class man to take charge of Iron and Bronze Foundries, must have thorough practical and technical knowledge of all branches of Foundry work. Must also have first-class experience of latest machine moulding methods. Present output 70/75 tons per week. — Apply, stating age, experience and salary required, to Alfred Herbert, Limited, Machine Tool Makers, Edgwick Works, Coventry.

A STEEL Foundry requires a FOREMAN MOULDER who must be thoroughly conversant in general steel foundry practice. Only experienced men should apply to nearest Employment Exchange, mentioning this Journal, and No. 2002. Persons employed on Government work need not apply.

WANTED, a competent FOREMAN for small Foundry engaged on Marine Engine Castings. Government controlled firm.—Apply, giving particulars to your nearest Employment Exchange, mentioning No. A4663. No person already on Government work will be engaged.

SITUATIONS VACANT AND WANTED (*continued*).

STEEL Foundry Furnace MANAGER and CHEMIST, wide experience in melting and finishing highest quality steels for castings and forgings, to meet existing specifications and tests, by Converter, Siemens and Electric Furnace processes, open for engagement; over military age.—Address, Box 940, Offices of the Foundry Trade Journal, 165, Strand, London, W.C.2.

AN experienced STEEL MELTER is also required. In answering this advertisement state wages required, experience, and testimonials. All replies to this advertisement should be addressed to your nearest Employment Exchange, mentioning this Journal. and No. 2004. Persons employed on Government work need not apply.

FOR SALE AND WANTED.

WANTED, Sand Blast Apparatus, in good working order.—Replies, stating age, condition, price, maker's size, etc., to Box 950, Offices of the Foundry Trade Journal, 165, Strand, London, W.C.2.

BRITISH PATENT No. 108,426, of 1916, relates to a drop flask Moulding Machine, whereby the system of moulding is rapid, accurate and inexpensive. Sale or licence.—Turner, 28, Plumper's Road. Sheffield.

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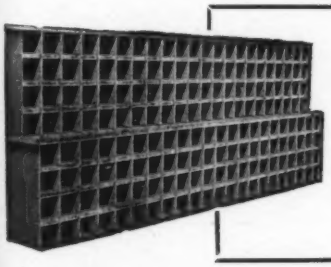
FOR SALE, Sand Blast Apparatus, by Tilghmans, with Compressor complete: in good working order; can be seen running by appointment. — Wycliffe Foundry Co., Ltd., Lutterworth.



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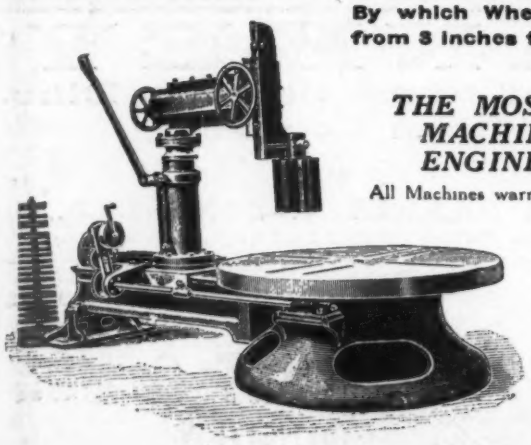

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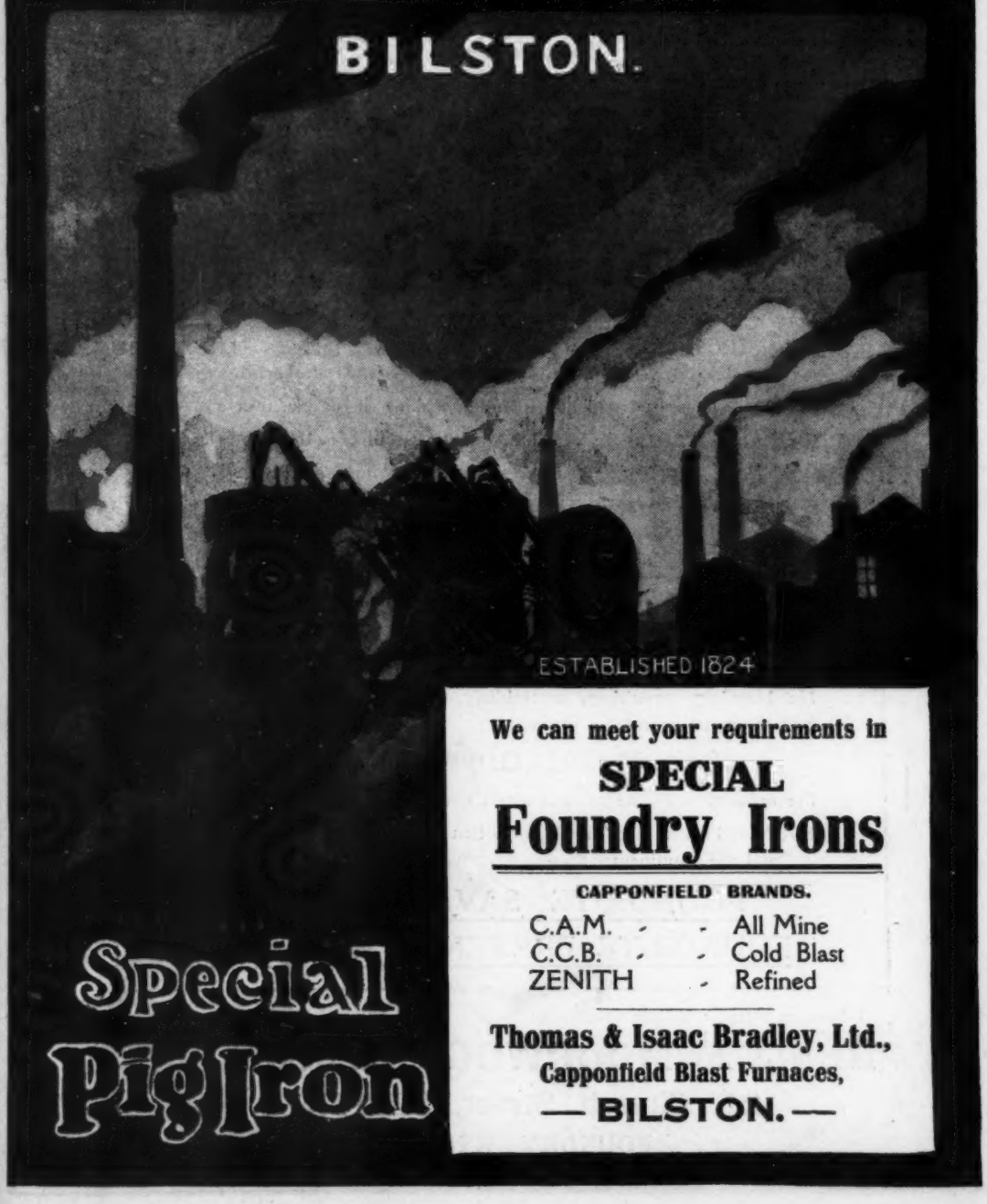

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FOUNDRITE is **the** binding material for moulding sand and cores.

FOUNDRITE SUPERSEDES and makes unnecessary all classes of **CORE GUM, LINSEED OIL and all other BINDING material.**

FOUNDRITE will renew old and burned sand, making it usable over and over again.

FOUNDRITE makes **CORES** unbreakable and the use of **core irons** unnecessary.

FOUNDRITE leaves **CORES** perfectly porous and does **not shrink.**

FOUNDRITE has been **"found right"** for all **Sand binding** in the Foundry **for all purposes.**

FOUNDRITE is supplied in **LIQUID** form ready for use. Dilute with Water.

The porosity of the core is perfect, and cores so made do not shrink.

No blowing, cracking, crumbling, honeycombing, or loss of strength can take place.

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For ordinary work the price is about One Penny per gallon.

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AS SUPPLIED TO H.M. WAR OFFICE.

THE ORIGINAL AND BEST CORE COMPOUND.

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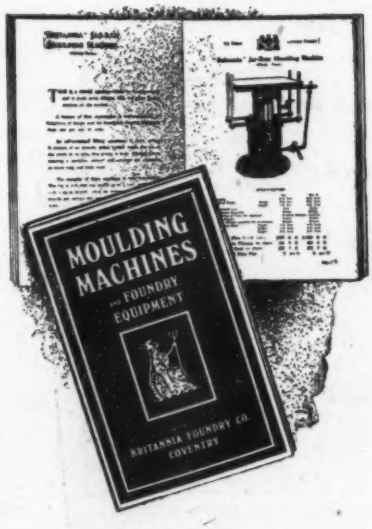

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from 28 lbs. capacity to 10 tons ,,
A large number usually in stock.

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These Ladles are manufactured by a patented process, each from a single steel plate without weld or rivet. They are extremely light, being at the same time the strongest and most durable in the market. Ladles to contain 56 lb. of metal only weigh about 7 lb. each. They are made of all capacities from 30 lb. to 60 cwt., with or without lips: also mounted or unmounted. They are also suitable for chemical and metallurgical processes. List of sections and prices on application to
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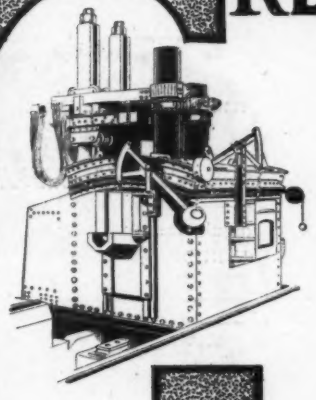

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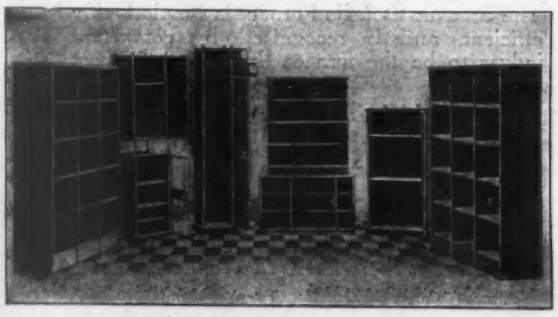

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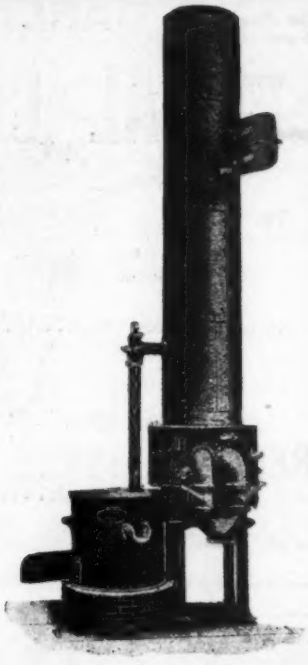

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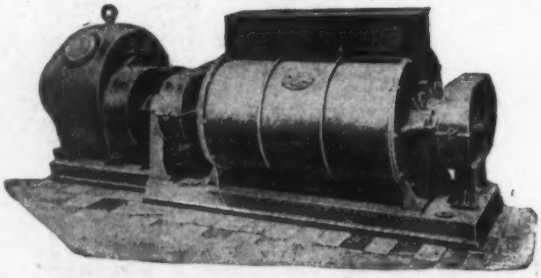

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BRABY for high grade **STEEL**
SHEETS and PLATES up to 15 FEET LONG.
RANGE OF GAUGES 8 to 30 W.G.
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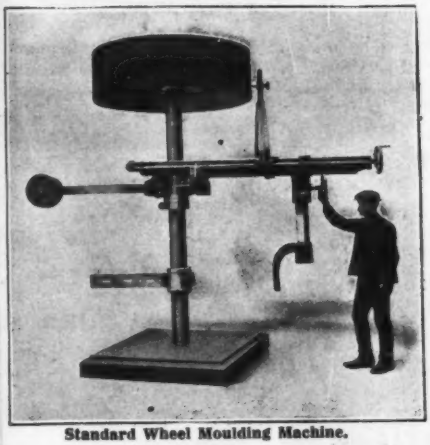

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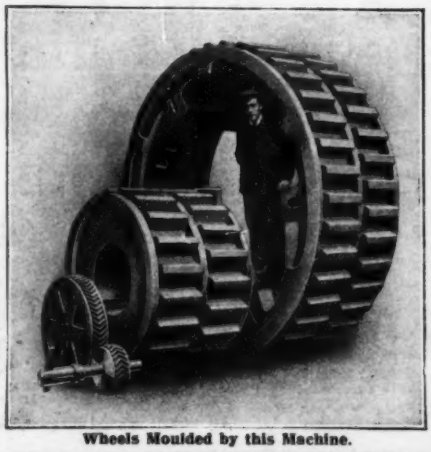

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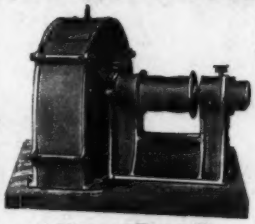

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